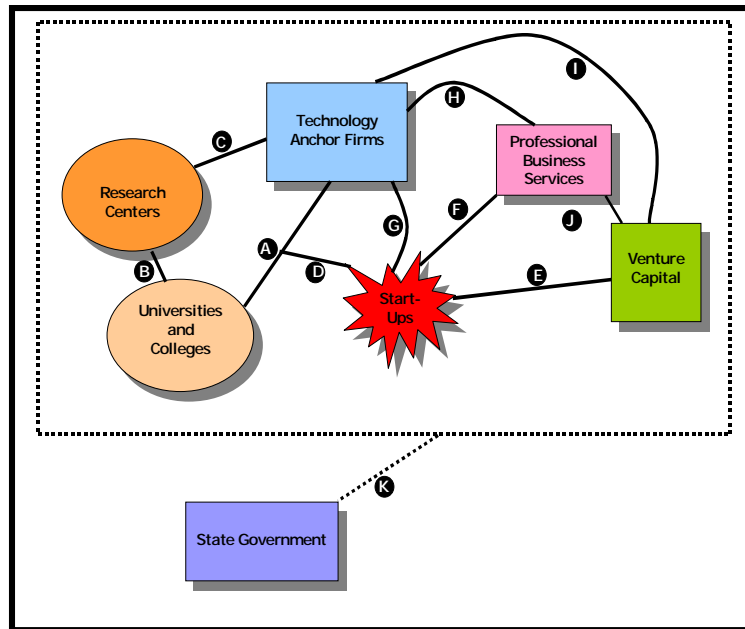


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UTAH TECHNOLOGY REPORT

TECHNOLOGY DEVELOPMENT STRATEGY



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EXECUTIVE SUMMARY

Success in creating high-tech clusters is now the distinguishing determinant of regional vitality.¹

The State of Utah is appropriately seeking regional economic growth through the development of technology. One of its primary economic growth strategies is to target and import technologies through the recruitment of companies. To further augment current economic growth initiatives, we recommend the enhancement of the “infrastructure” for growing companies from embryo to maturity, advancing current strategies aimed at prospering Utah’s core competencies in biotechnology and software; and promoting a culture that richly supports entrepreneurs.

Utah possesses good research centers and innovative thinkers in high technology sectors. Utah’s potential can further be realized by building upon the mechanisms through which innovation is transformed into statewide economic prosperity. The State government can aid in developing a habitat or system that breeds innovation and world-class, high-tech companies.

The following summarizes our observations and resulting recommendations:

OBSERVATIONS

Utah Technology Development Initiatives

Observation #1: Utah’s current economic growth initiatives appropriately focus on the regional development of technology. Utah’s technology initiatives can be reinforced through the development of technology growth networks.

Observation #2: The State government can aid in developing a habitat or system that breeds innovation and world-class, high-tech companies through increasing research and entrepreneurial activities at its universities; encouraging and facilitating partnering with industry; and providing capital and small business assistance services.

Observation #3: Low labor costs cannot be sustained in Utah’s growing economy². Productivity is an effective indicator of economic growth and increased standard of living and reflects high per-capita income job growth.

Observation #4: Utah’s standard of living is more a product of its low cost of living than the productivity of its high-tech industrial clusters.

Models for High-Tech Development

Observation #5: The development of Silicon Valley, Route 128, and Denver would be difficult to duplicate as it spanned many decades and was heavily subsidized by the federal government; the impetus being World War II and the Cold War. In contrast, Austin's development was more deliberate and is thus a more relevant source when formulating recommendations.

Observation #6: In the economic models, a visionary at the university or state government level initiated collaboration between the university, the high-tech industry, and the general business community: Dr. Fred Terman, Silicon Valley; Dr. Vannevar Bush, Route 128; Governor Roy Romer, Denver; Dr. George Kozmetsky, Austin. The visionaries also encouraged entrepreneurship and provided resources for the development of start-ups.

Observation #7: The foundation of an effective technology development or innovation system is a strong university-industry relationship. In each case study, a strong research university played a central role in the development of innovative technologies.

Observation #8: Anchor firms produce an agglomeration effect. That is, they possess resources that are attractive to other firms—typically suppliers, customers, and strategic partners. This clustering effect eventually leads to a “critical mass” of companies, and desirable scale economies result. Anchor companies tend to be home grown; rarely are technological competencies imported.

Observation #9: An effective technology innovation and commercialization system involves the interplay of a tight network of components: Universities, Anchor Companies, Research Centers, Start-Ups, Professional Business Services, Venture Capital, and State Government.

Observation #10: Rapid technology growth and economic development within an industry take place around a clustering of spatially and intellectually proximate companies.

Observation #11: Professional business services are attracted to a development system once the quality of start-ups and availability of capital justify location within the region.

Observation #12: Labor, firm, and industrial cultures play a major role in the success of the system in creating and developing innovative technologies.

Observation #13: A state government should facilitate the technology development network through the formation of business policies, business assistance programs, labor force development, research funding, capital creation, and infrastructure development.

Utah Technology Landscape

Observation #14: Utah has a strong research presence in its universities and research centers, especially in fields such as biotechnology, computer science, and engineering.

Observation #15: Utah's universities need to develop stronger relationships with industry. Collaboration in research and industry-related projects is less developed when compared to other high-tech regions.

Observation #16: Utah's labor force changes jobs less frequently than its counterpart in Silicon Valley. When compared to Silicon Valley, firms in Utah are more hierarchically structure and not as meritocratic. Additionally, Utah firms tend to be more closed, resulting in less communication and collaboration.

Observation #17: High-tech centers such as Silicon Valley, Boston, Austin, and Denver provide models for Utah's high-tech development. These economies possess technology innovation and commercialization systems that not only generate start-ups, but also grow industry-leading companies.

Observation #18: The *Utah Venture Report* indicated that 61 percent of the respondents to their Utah technology poll stated that the lack of capital was one of the biggest problems faced in growing a business in Utah. Success of those seeking funding has been limited, 68.7 percent of the respondents to the poll said they absolutely would expand their operations if the capital were available.³

RECOMMENDATIONS

Education

Recommendation #1: Bring additional world-class knowledge to the state through the attraction of academics for lectures, seminars, professorships, and research positions.

Recommendation #2: Attract an individual with an extensive high-tech network that could assume a visionary role in Utah's technology development to an important academic administration position. Attracting such an individual should be considered a long-term investment, requiring appropriate compensation. A leading high-tech figure could greatly enhance a university's role in state economic development.

Recommendation #3: Encourage universities to reward technological innovation by including it in the criteria for tenure and promotion. Establish a super-scale of remuneration, or find other means to compensate those new and existing faculty whose superstar status is sought for designated programs.

Recommendation #4: Create additional specialized schools and departments within the universities that develop the real-world application of new technologies. Meet with experts to discuss what new high-tech school could be established at the University of Utah or Utah State University.

Recommendation #5: Advance the development and interest of technology and entrepreneurship at a young age by organizing engineering and entrepreneurial projects between Utah students K-12 and local industry.

Recommendation #6: Create a statewide electronic network that connects educational institutions at all levels, linking classrooms, libraries, laboratories, workshops and conference rooms via voice, data, graphics and images-based interactive communications.

Recommendation #7: Create an Industrial Education Committee comprised of educators and business leaders to discuss how to further develop a strategic workforce education program tailored to technology industry needs.

Recommendation #8: Establish programs at the State universities that further facilitate collaboration with industry in research and development initiatives. Play an influential role in recruiting leading companies to establish partnerships with researchers at the State's institutions.

Recommendation #9: Play an active role in the development of entrepreneur programs at State universities. Bachelors and master's programs in computer science, engineering, and the life sciences should emphasize entrepreneurial training and incentives.

Recommendation #10: Develop local social networks that leverage Utah's high-tech growth and support its high-tech companies. Instigate forums for discussion among academics and industry experts.

Businesses

Recommendation #11: Encourage further university-industry collaboration by offering a generous R&D tax credit to companies that engage in research and development activities with the State's universities.

Recommendation #12: Plan for and develop additional industrial parks where clusters of companies can locate. Utah should continue developing a critical mass of companies in close proximity as part of the innovation system. This allows companies to drive each other to innovate while employees develop informal networks of learning.

Recommendation #13: When recruiting companies, Utah should continue to focus on promising, innovative start-ups and intellectual capital-producing divisions of anchor companies. This involves attracting companies that build upon Utah's existing

competencies in biotechnology, software, and specialized computer hardware components.

Recommendation #14: Offer a simple, coordinated, and expeditious process for obtaining multiple new business permits and approvals.

Recommendation #15: Work with research programs in competing for federal grants by more aggressively pursuing federal funding for university research.

Recommendation #16: Proliferate non-profit incubator organizations that provide capital, technology transfer assistance, and contacts for new start-ups. Ideally these organizations would coordinate support services to entrepreneurs through the commercialization process. Specifically, these centers could provide low-cost facilities; and connect entrepreneurs to capital, business skills training, and university training programs

Recommendation #17: Create the Utah Science and Technology Council to identify barriers to growth in the science and technology industries and recommend measures to reduce such barriers. The council should be composed of the state's leading CEOs, universities and government officials.

Recommendation #18: Host or sponsor high-tech industry trade shows to the State that will promote the flow of ideas between companies and draw attention to the State.

Capital

Recommendation #19: Strengthen the role of state government in raising, attracting, and retaining venture capital. The following are suggested strategies that the state could employ to facilitate this process:

Aggressive strategy. Invest state-controlled funds in venture capital pools. Most venture capital comes from insurance companies, pension funds, university endowments, at least in established areas. Regions at an earlier stage in the process should ramp up public-sector VC funds (by diversifying their pension fund portfolios, for example).

Neutral strategy. Encourage angel investing through state-run matchmaking programs. States can catalyze venture funding by holding "venture network" forums that bring the state's most likely investors (prominent, wealthy individuals) and its best entrepreneurs together for periodic (bimonthly) conferences. The state could also guarantee a 6 percent return for in-state investment by Industrial Loan Corporations. This could prompt these corporations to invest, in Utah, the hundreds of millions of dollars they are required to invest locally by law.⁴

Physical Infrastructure

Recommendation #20: Continue to guide development to appropriate locations where infrastructure is already in place, where the environmental conditions are sufficiently stable to sustain further growth, where efficient public transit service is available, and where appropriate urban housing and services exist for a higher standard of living.

Recommendation #21: Increase the frequency of non-stop international flights from Salt Lake International Airport to airports around the world. International access can enhance the State's ability to do business globally and to attract foreign investment and collaboration.

Recommendation #22: Work towards establishing a metroplex by linking the Salt Lake and Provo/Orem economies. One way to instigate this process is through the issuance of State bonds to develop TRAX from Ogden to Spanish Fork within three years, as infrastructure investment is directly related to the ability of the economy to grow and increase its productivity.

State

Recommendation #23: Utah should focus on raising the standard of living for all citizens by increasing per-capita income through high-productivity industries. In this next stage of growth, job creation initiatives should be focused on per-capita income.

Recommendation #24: Encourage greater state, regional, and local cooperation for economic development. More coordination between Utah's economic development programs can reinforce the State's high-tech network.

Recommendation #25: Further develop Utah's ethnic centers in sections of downtown Salt Lake such as "Little Mexico," "Greek Town," "China Town," and others, to highlight Utah's diverse cultures⁵⁶.

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INTRODUCTION

ECONOMIC GOAL OF THE STATE OF UTAH:

PRODUCE A HIGH AND RISING STANDARD OF LIVING FOR ALL CITIZENS OF THE STATE

According to renowned business scholar Michael Porter, the economic goal of a state should be to produce a high and rising standard of living for its citizens.⁷ This overarching declaration is critical to future policy initiatives and justifies a concerted effort to develop high technology within the state. By identifying the production of a high and rising standard of living as *the* end goal, various policy issues such as technology development are viewed appropriately as a means.

This report will elucidate the principles upon which this strategy can be implemented to perpetually increase the standard of living for all citizens of the State of Utah. A unique model for technology development--a technology innovation and commercialization system--will be presented. We submit a prefatory caveat – much of the functioning of this technology development system is beyond the scope and capacity of the Utah State Government. Notwithstanding, we maintain that the role of the State is essential to initiate the process, and to provide the vision of Utah as a premier, global, high-tech center.

INCREASING THE STANDARD OF LIVING THROUGH TECHNOLOGY

*Productivity is the prime determinant in the long run of a nation's standard of living, for it is the root cause of national per capita income.... A rising standard of living depends on the capacity of a nation's firms to achieve high levels of productivity and to increase productivity over time.... Sustained productivity growth requires that an economy continually upgrade itself.*⁸

Productivity can be defined as one unit output for every unit of input. For example, with regard to employees, it could be measured by output per hour. The link between technology, productivity, and a high standard of living is a relationship that has placed technology on the agenda of every region and state in the nation. High-tech development offers the type of productivity gains that can increase the standard of living to previously unattainable levels.

Although Utah's per-capita income is low (see **Appendix A**), Utah's standard of living remains relatively high for a portion of its citizens because of a lower cost of living. A low cost of living, however, is not sustainable in the long run, especially when considering Utah's high-growth population and workforce. This is demonstrated by the fact that a low cost of living is reflective of the availability of resources in relation to

market demand. As the availability of energy, real estate, etc. remains constant while the population increases, prices will increase and drive the cost of living up. Income brought to the State through globally competitive, high-tech companies can help the State maintain and even increase the standard of living despite a rising cost of living.

How does Utah's high-tech economy compare with other major regional economies on the important measure of productivity? On average, Utah companies are not as productive as their counterparts in other regions such as Silicon Valley, Boston, Austin, and Denver (see **Appendices B – F**).

There are two important implications of this analysis:

- 1) Utah's high standard of living, therefore, is more a product of its low cost of living rather than the productivity of its high-tech industrial clusters. Unless Utah increases productivity through high-tech development, in the long run, Utah's high standard of living cannot be increased, or even maintained.
- 2) The region or industrial system in which a company operates affects the productivity of that company. In other words, unless an effective industrial system is developed, a company cannot realize its full potential.

Companies that form in Utah, generally, do not thrive in comparison to companies in more established high-tech regions. Utah's business environment has traditionally had difficulty in supporting the growth and competitiveness of high-tech companies. Anecdotal evidence validates this assertion: Word Perfect; TenFold; Evans and Sutherland gave birth to Silicon Graphics - Jim Clark, Pixar - Edwin Catmull, and Adobe - John Warnock; Novell gave birth to US Web and BEA Systems; Also see **Appendix G**. These companies were established elsewhere, many in Silicon Valley, because Utah's business environment was, at the time, unable to support their growth. Iomega's recent decision to relocate to San Diego may be symptomatic of the same phenomenon. The recommendations contained in this report can help advance Utah's current technology development strategy to sustain promising start-ups and anchor companies.

Technology, especially disruptive technology, creates new growth and wealth for an economy. The term *disruptive technology* is attributed to Harvard Business School professor Clayton Christensen.⁹ Disruptive technologies are not just upgrades of existing products or technologies but are technologies that change the standards of an entire industry. Disruptive technologies are revolutionary not evolutionary, and, as such, constitute new market opportunities for businesses and new investment requirements for consumers. Disruptive technologies are best brought to market through start-ups and entrepreneurial activities. According to Christensen, by definition, new growth is disruptive.¹⁰ The role of the state government as a facilitator for disruption is a key requirement for a technology commercialization system.

Not only does new technology create new companies, new industries, and higher wages, but it also promotes a region-wide or statewide benefit for all citizens. For example, year 2000 capital gains and stock option income as a percentage of California State General Fund revenues was 23.1%.¹¹ In recent years, Californians have collected huge amounts of income--\$84 billion in all last year--from stock options, which has helped fuel state surpluses. Ten companies--household names such as Cisco Systems, Intel, Hewlett Packard and Wells Fargo--account for 60% of the stock option income. Cisco alone may account for as much as 10% of all income from options in California.¹² By leveraging the enormous gains of a high-tech center such as Silicon Valley, a state can invest surpluses from things like the exercise of stock options, into infrastructure and rural development projects. In sum, as Salt Lake is developed, Kanab can benefit.

FORMULATING A STRATEGY FOR INNOVATION

"Competitive strategy is about being different."¹³

Michael Porter's groundbreaking book, *The Competitive Advantage of Nations*, has helped countless nations and states understand the bases upon which a regional economy can be competitive within its industries, and provide a higher standard of living for its citizens. Comparative advantages such as low wages cannot be sustained in the long run and should not be construed as competitive advantages. Industries in which labor costs are important for a state or regional economy to be competitive also tend to have industry structures that support low returns on investment.ⁱ

Development programs often target new industries based on factor cost advantages, with no strategy for moving beyond them. Nations (states) in this situation will face a continual threat of losing competitive position . . . (Porter, 1990)

Utah's strategy should focus on developing sustainable advantages in its innovation system. A sustainable advantage in a regional economy is one that is not easy to replicate. As evidenced by the success of Silicon Valley and Route 128 in Boston--and the inability of states and nations to duplicate this success--thriving high-tech regional economies possess key aspects of their industrial networks and innovation systems that are not easily replicated. The following two examples give credence to the notion that a state's economic initiatives must be highly strategic to be successful:

- **Job-focused** - An interview with Dr. Michael Fogarty of Cleveland's Case Western Reserve University revealed that region's mistakes¹⁴. Between 1983 and 2000 the Cleveland metropolitan area increased the number of jobs in the area by 400,000. At the same time, however, worker productivity, and per-capita income fell in relation to the US average. In hindsight, the goal of flatly increasing the number of jobs was not strategic and actually hurt the region's ability to grow. Dr. Fogarty indicated that the mistake of the region was in being too "job-focused."

• **Graduate-focused** – Initiatives to increase the education of engineers and computer science students should be undertaken simultaneously with the development of ways to keep this talent in-state through the formation of a technology innovation and commercialization system. Such initiatives could help Utah retain its high-tech work force. As it is now, approximately 40 percent of the Engineering and Computer Science students at the University of Utah leave the State to work elsewhere after graduation. About half of the Engineering and Computer Science students at Utah State University leave the state after graduation.

Firms create competitive advantage by perceiving or discovering new and better ways to compete in an industry and bringing them to market, which is ultimately an act of innovation.... Technological change can create new possibilities for the design of a product, the way it is marketed, produced, or delivered, and the ancillary services provided. It is the most common precursor of strategic innovation. (Porter, 1990)

The question is how does a state or regional economy develop a system whereby a constant stream of innovative technology is commercialized over the long term?¹⁵ How does this system produce and develop the specialized skills and knowledge necessary to systematically commercialize high technology? How did Silicon Valley, Route 128, Austin, and Denver-Boulder develop into high-tech centers? What aspects of their development were deliberate and how much of it was random or arbitrary? How does a high-tech company achieve great productivity in Silicon Valley? These issues, as well as more definitive answers concerning how an effective technology innovation and commercialization system functions, will be addressed in this report.

Leading industrial districts seem to be home grown, and usually arise spontaneously around some catalyst - a major research university that happens to be interested in what turns out to be the "right thing", one company that has a commercial success and builds a network of suppliers and spin-offs, and so forth. Importing companies is a problem because what tend to be attracted are production and sales/marketing functions rather than intellectual capital-creating research facilities. That Gateway has set up an assembly plant here is less relevant than that Intel plans to set up an R&D facility. The other issue is that the knowledge sharing that forms the foundations of these regional clusters is based on broad and deep social interactions that engender a level of trust and cooperation that is not typically available to a newcomer, particularly one seen as a mercenary. The role of government is problematic. Mike Porter says that government should encourage competition by a strong anti-trust stance (but must permit and encourage sharing of knowledge development) and should work to build physical and (especially) intellectual infrastructure to encourage innovative activities and competition. Other writers see government being more directly involved, but overall, the heavy hand of the state is probably inimical to true innovation. Trying to beat existing competitors with similar products and technologies is only going to result, at best, in price

competition. So, Malaysia can come to dominate the market for computer peripherals based on cheap labor, but will not be able to use this position to be a world force in the business, just a manufacturing site.

Dr. Stephen B. Tallman
Professor of Management
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It is unlikely that a state will be successful in the long run by importing technologies. Presumably, other states will want to import firms with exciting technologies just as much as Utah. In the absence of some other compelling advantage or some first mover advantage rooted in other states lack of foresight, it is not likely that a state could sustain such an advantage. Indeed, the likely outcome is some kind of bidding war where states give away as much as they benefit.

Dr. William Hesterly
Professor of Management
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Utah could benefit by developing a long-term strategy based upon a model or multi-faceted system patterned after the technology development systems of a Silicon Valley or Austin. The focus should be on *new growth* and *new technologies*. It is possible that the majority of Utah's future economic growth will be from promising technologies that have yet to be developed and commercialized.

While an important part of a strategy, marketing a state to attract companies to locate headquarters or portions of their organizations to a region is not a comprehensive strategy for economic development. A recent report by the Chicago Federal Reserve Bank highlighted the big companies expanding or relocating headquarters in the 1990's. San Francisco gained 39 major corporate headquarters, with Houston, Dallas, and Atlanta at 29, 28, and 25 respectively. Yet, "despite all the movement, some things haven't changed. Roughly two-thirds of major corporations remain based in the top 20 metro areas, the same as 10 years ago."¹⁶

RESEARCH METHODS

Our analysis, the formulation of Utah's technology development model, and recommendations for strategic implementation are based upon sources including, but not limited to

- In-depth case studies of four prominent high-tech regions.
- Interviews with academics and other regional development experts locally and from universities such as Harvard and Stanford.
- Books outlining the development of Silicon Valley and Route 128 by experts such as Annalee Saxenian and Chong Moon-Lee.

- Numerous articles consisting of a body of academic literature on regional high-tech development by authors such as Ross Devol, Ann Markusen, and Annalee Saxenian.
- Literature on technology development and competitiveness by scholars such as Clayton Christensen and Michael Porter.
- Data analysis using Standard & Poor's corporate financial data for public companies.

CASE STUDIES

In order to formulate a model for technology development in the State of Utah, we undertook the study of four major high-tech regional economies:

- Austin, Texas
- Denver-Boulder, Colorado
- Boston's Route 128
- Silicon Valley in northern California

We postulated that we would find that each region differed as to the degree of randomness in its development as a high-tech center. We anticipated, however, that we would find similarities in the way the technology development systems in each region generated technological innovation and the effectiveness of the systems in translating this innovation into companies and commercialized products.



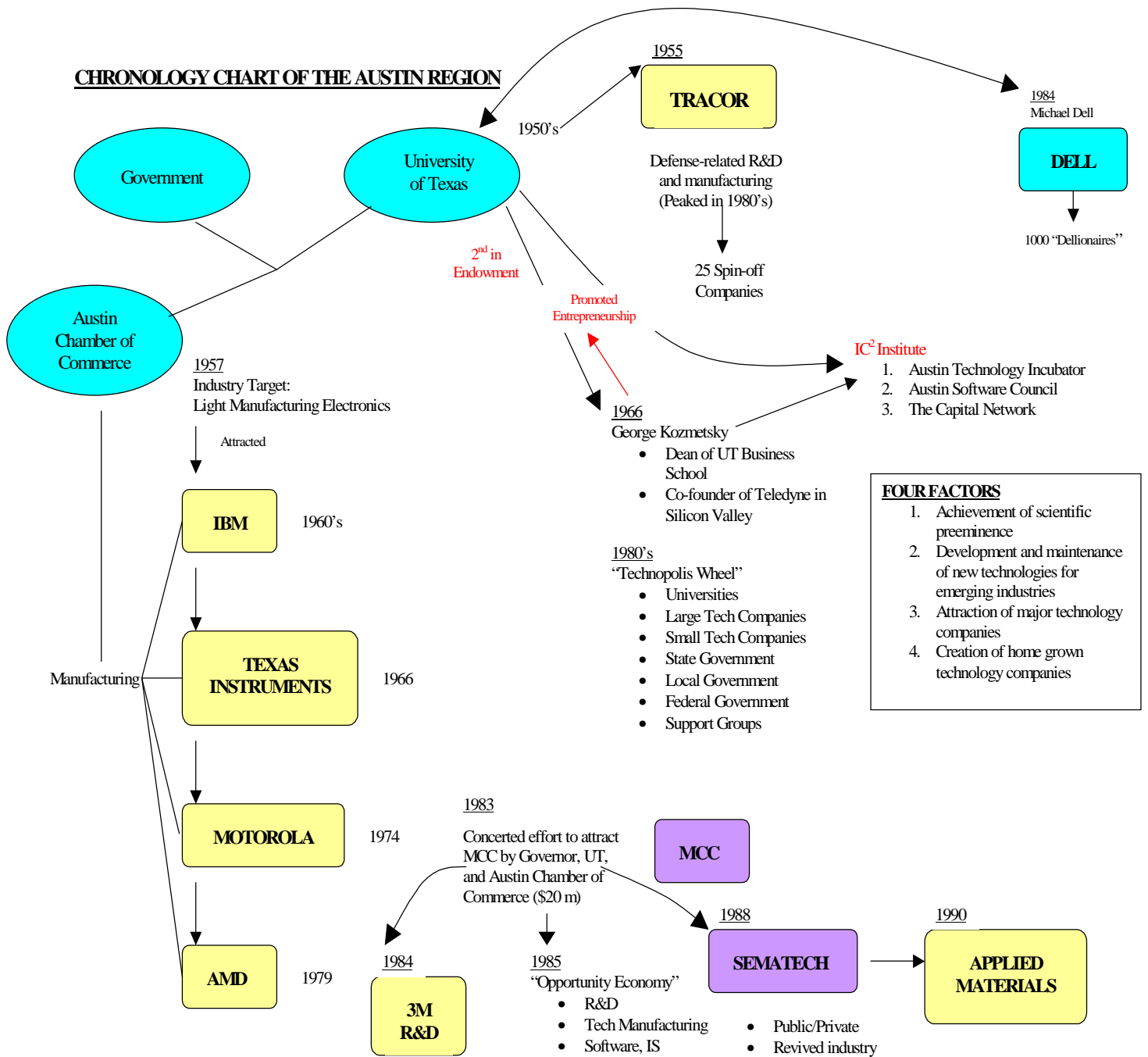
AUSTIN

It should be noted that the following profile and graphic chronology draws extensively upon documents from Jonathan Miller, European Commission Delegation; and the Greater Austin Chamber of Commerce.

The Austin technology-region did not occur merely by a random occurrence of events, in contrast to the Silicon Valley and Route 128 regions. Rather, Austin's development was a carefully planned and articulated vision driven by the Greater Austin Chamber of Commerce, in conjunction with noted visionary Dr. George Kozmetsky, and engineered through a synergistic relationship borne out of close coordination efforts between three key parties: the private sector, the University of Texas, and the government. The goal of this endeavor was to cultivate a tight network of innovative partnerships and close relationships within the Austin region.

Each party has played a key role in developing Austin's vision for "Creating an Opportunity Economy." The Greater Austin Chamber of Commerce has taken the lead in orchestrating this endeavor and has been successful in aggressively recruiting high-tech giants to relocate new plants in Austin. These include 3M, AMD, Motorola, and Applied Materials.

A premier research university, with an endowment second only to Harvard, the University of Texas has provided resources, both financial and talent, to offer significant incentives to prospective relocators. Local, county, and state government have worked to provide financial incentives and an attractive business environment, as well as to provide the necessary salesmanship by the governor and the mayor.



CHRONOLOGY OF KEY EVENTS

- Pre-1955** Texas State government and the University of Texas at Austin were the main drivers of Austin's regional economy, employing a majority of the area's workforce.
- 1955** Dr. Frank McBee, a UT engineering professor, founds Tracor, Inc., a small defense-related R&D and manufacturing company. More than 25 Austin high-tech companies were later spun-off from Tracor into separate companies.
- 1957** The Greater Austin Chamber of Commerce commissions a study on how to diversify Austin's economy. The report recommends developing light manufacturing with a focus on the electronics industry.
- Early 1960's** Austin receives its first win in light electronics manufacturing, as IBM opens a plant to manufacture Selectric typewriters.
- 1966** Dr. George Kozmetsky, co-founder of Teledyne in Silicon Valley and one of the most influential leaders in the development of Austin's high-tech regional economy, becomes Dean of UT-Austin's College of Business Administration.
- Texas Instruments establishes an electronics manufacturing facility in the Austin region.
- 1974** Motorola sets up a manufacturing plant in Austin.
- 1979** IC² Institute (Innovation, Creativity, and Capital) is developed by Dr. Kozmetsky as a public-private partnership effort, with a primary objective of developing entrepreneurship.
- Advanced Micro Design relocates some of its manufacturing operations to the Austin area.
- 1980's** George Kozmetsky plays an influential role in developing the "Technopolis Wheel," citing seven major segments necessary to create a technopolis or high-technology-based city. (See chronology chart.)
- Often considered the watershed event in Austin's high-tech development, the city won the nationwide competition for Microelectronics and Computer Technology Corporation (MCC), the first private sector, high-technology consortium created to promote US technological leadership in electronics.

An all-out collaborative effort between Governor Mark White's office, the University of Texas' College of Engineering, and the business community led by the Austin Chamber of Commerce, put together a package of incentives totaling \$20 million. In the view of many, landing MCC served as the "trigger point" for Austin's development as a future high-tech center.

1984

Michael Dell founds Dell Computer Corp., what would later become Austin's primary anchor firm. Dell's public offering would go on to create more than 1,000 *Dellionaires*; those Dell employees who hold stock options over \$1 million, infusing capital back into Austin's economy.

3M Corporation relocated the first of three divisions from Minnesota, following another successful recruitment. The new facility contained research and development laboratories to be staffed by hundreds of scientists and technicians.

The Greater Austin Chamber of Commerce commissioned a new long-range economic plan entitled "Creating an Opportunity Economy." The study defined Austin's future in terms of a five-sector economy, which includes the following three science- and technology-related sectors:

- Research and Development or "Discovery businesses that create new knowledge" Technology Manufacturing or "Companies that translate new knowledge into products or processes"
- Technology-based Information or "Software, electronic databases and publishing, telecommunications, as the nation evolved toward an 'information society'"

1988

Austin recruits prominent semiconductor research and development consortium Sematech. A public-private partnership between the Federal government and the domestic semiconductor industry created to stave off competition from Japan; Sematech is credited by many to be responsible for the revival of the U.S. semiconductor industry.

As US News & World Report states, "MCC and Sematech give Austin the 'critical mass' of high-tech manufacturers, suppliers, and workers that allows businesses to sustain themselves—and expand."

1989

Austin Technology Incubator (ATI) is developed by Dr. Kozmetsky and coined "do-tank." ATI was designed to serve as a real-world laboratory for promising entrepreneurs, providing low-rent space and office equipment, as well as professional assistance and access to venture capital, consulting services and other companies, for those start-ups

which offer the most potential for growth. To date, ATI's 45 graduate and 20 resident companies have created more than 1,500 jobs, generated \$183 million in revenues for FY97, raised \$170 million in capital, and include five publicly-traded companies.

Another Kozmetsky/IC² creation is the Austin Software Council (ASC), whose mission is to expand and enhance the professional and technical infrastructure in Austin, promote products and services based on locally developed technologies, and establish an active network of professionals.

Dr. Kozmetsky also spearheads The Capital Network (TCN) in order to address the needs of pairing aspiring entrepreneurs with venture capital.

Today, the Capital Network (TCN) is the nation's largest and most successful venture capital network. TCN is a non-profit, economic development organization with a goal of providing entrepreneurial ventures with training and access to investors. Specifically, the organization offers investor-to-entrepreneur introduction services, educational programs, venture capital conferences, seminars, literature, software, and an extensive "know-how network" of experts and advisors.

- | | |
|-------------|---|
| 1990 | Semiconductor equipment maker Applied Materials sets up shop in Austin in 1990 after Sematech's arrival. |
| 1998 | University of Texas opens an Office of Technology Licensing and Intellectual Property to coordinate and promote UT commercialization efforts from its faculty and research scientists and to raise licensing revenues for the university. |

AUSTIN TODAY

As a result of private sector, University of Texas, and government efforts, today the high-tech Austin economy has reached a critical mass of core industry clusters (see **Appendix H**) in the area of semiconductors/electronics, computers/peripherals, and software.

Semiconductors and electronics is one of the most important high-tech sectors in Austin today. Currently, seventy-five semiconductor-related manufacturers employ more than 21,000 workers. Most of this growth has come in the last decade through relocations of large manufacturers and R&D facilities such as Motorola, Advanced Micro Design, Samsung, Sematech, Applied Materials (the largest semiconductor equipment supplier in the U.S.), Tokyo Electron, and Cypress Semiconductor.

The computers and peripherals cluster is comprised of approximately 195 companies, employing more than 36,500 people manufacturing personal computers, printers,

monitors, and storage devices. The biggest players are IBM and Dell. Computer and electronics manufacturers created 6,000 new jobs in 1998, for a total of 20,000 since 1993. One of the most important aspects of this cluster is its synergy with the semiconductor cluster.

The software sector in Austin has grown faster than both Seattle and Silicon Valley, at an annual average rate of 22% between 1990 and 1996. In 1998, the Austin region had 200 new technology start-ups, of which 70% were software companies. Additionally, 650 software companies employed more than 24,500 people in the Austin area. Leading companies include CSC Continuum, Tivoli Systems, Pervasive Software and Trilogy Development.

In contrast to the semiconductor industry, where all of the manufacturers are transplants, much of Austin's software industry is homegrown, fueled by improving access to venture capital.

Today, the combined private and public sector in Austin spend approximately \$1.4 billion in research and development annually. Since 1990, technology patents awarded to area inventors have doubled, from 352 to 831 in 1996.

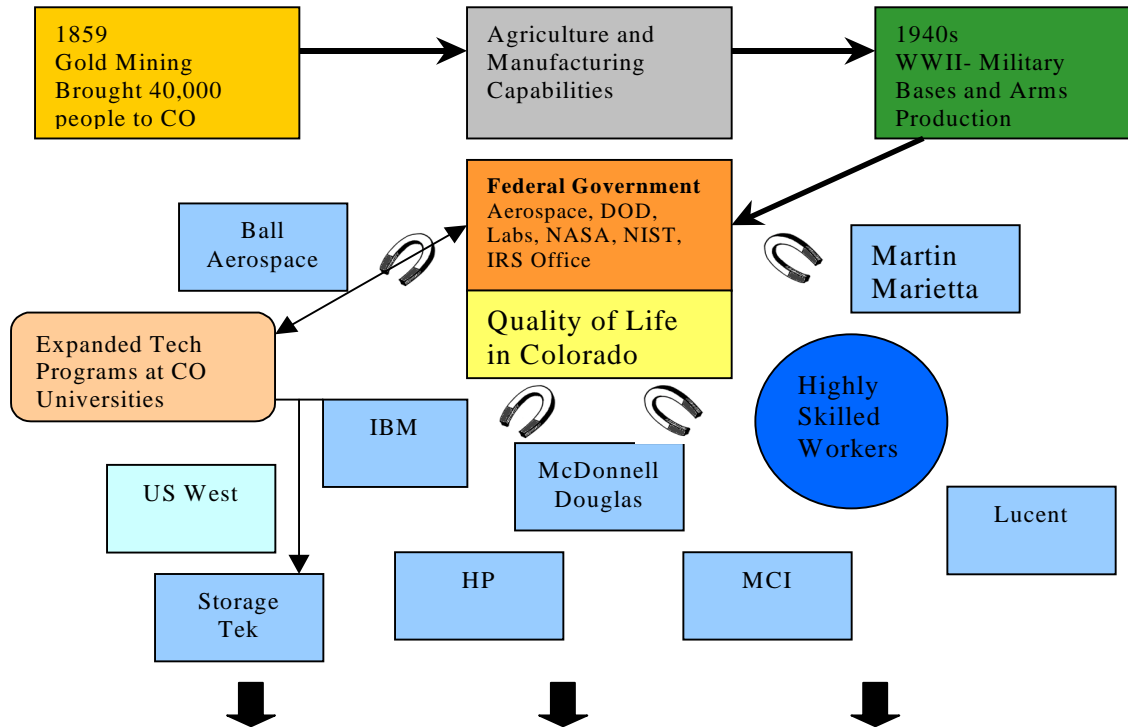


DENVER

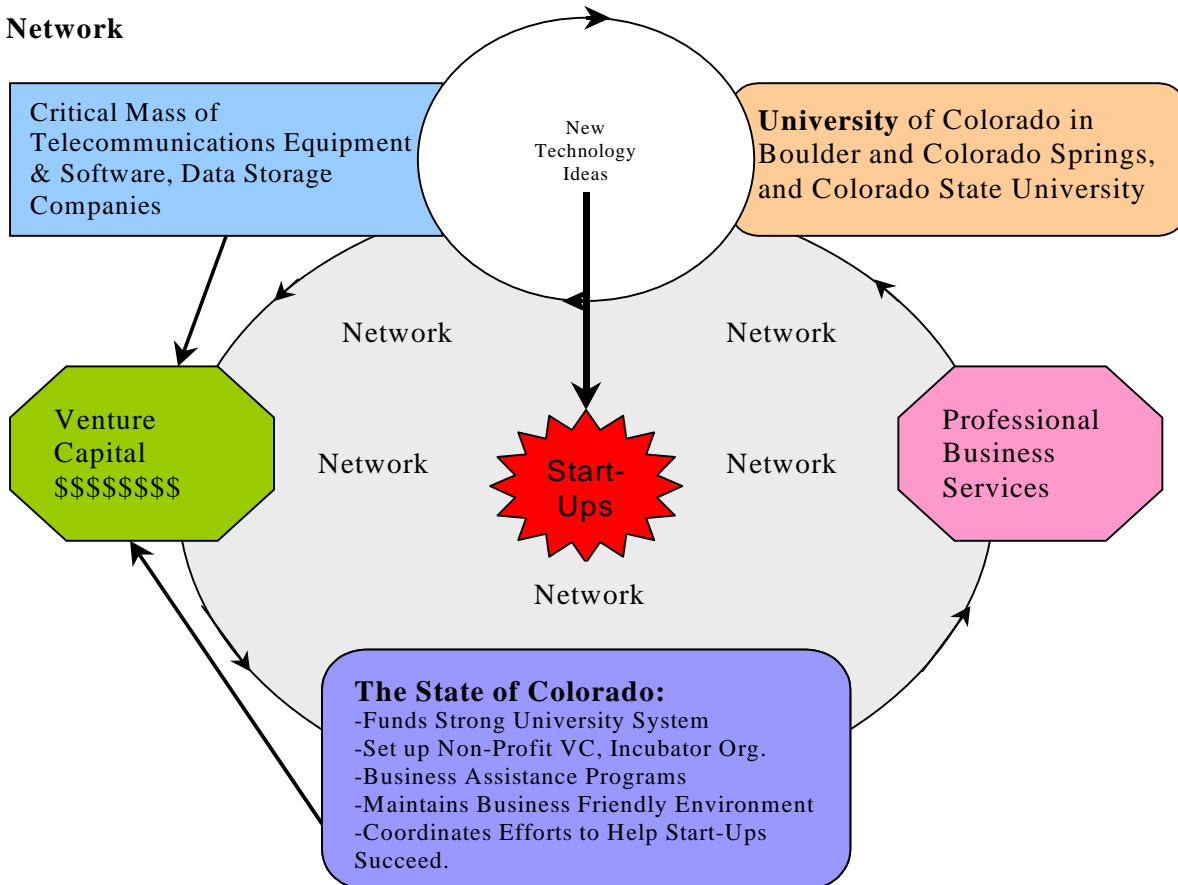
While today, Colorado's high-tech economy is growing rapidly, the Colorado economy has not always been a prospering high-tech center. In the mid 1980s, Colorado was in the middle of a "severe economic depression."¹⁷ However, Colorado has turned itself around and become "one of the premiere locations in the US to operate a high-tech business."¹⁸ Specifically, the State of Colorado has taken an active roll in the development of its high-tech sector and has done much to help spur economic growth.

Colorado's Technology Model

Endowment



Network



Where Colorado Stands

The Corporation for Enterprise Development compiles an annual "Report Card for the States" to evaluate how well each state is doing in over 70 measures. Colorado received all A's in the three major economic indexes, which are performance, business vitality, and development capacity. Colorado also ranked well on other key technology measures:

- 2nd in the amount of small business investment research;
- 10th in patents issued;
- 9th in university spin-outs;
- 3rd in households with computer;
- 2nd in technology companies;
- 1st in educational attainment-college graduates;
- 8th in university research & development;
- 9th in Federal R & D;
- 4th Science/Engineering graduate students; and
- 3rd in venture capital investment ¹⁹.

Another reputable technology ranking source, AeA's Cyberstates 2001, ranks Colorado number one in concentration of tech workers. Colorado also did well in several other AeA's Cyberstates 2001 categories:

- 180,866 high-tech workers (10th ranked cyberstate)
- 75,600 jobs added between 1994 and 2000, ranked 4th nationwide
- High-tech firms employ 97 of every 1,000 private sector workers, ranked 1st nationwide
- High-tech workers earned an average wage of \$66,378 (8th ranked), or 93% more than the average private sector wage
- Colorado's average high-tech wage increased 33%, or by \$16,400, between 1994 and 1999, adjusted for inflation
- A high-tech payroll of \$11.1 billion in 1999, ranked 9th nationwide
- 6,383 high-tech establishments in 1999, ranked 12th nationwide
- High-tech exports totaled \$4.1 billion, ranked 11th nationwide
- High-tech exports represented 62% of Colorado's exports
- Venture capital investments of \$4.7 billion, ranked 5th nationwide
- R&D expenditures of \$4.6 billion in 1998, ranked 14th nationwide
- Home computer penetration reached 63%, ranked 4th nationwide
- Home Internet use totaled 52%, ranked 3rd nationwide

Colorado's Technology Endowment

Several factors have contributed to Colorado's success as a high-tech industrial center. Colorado's economy boomed in 1859, after gold was discovered in Cherry Creek in

1858. During the year 1859 approximately 40,000 people migrated to Colorado. Mining brought with it agriculture and manufacturing, and thus, Colorado developed into a major industrial center in the West.

After the discovery of gold and the industrial boom around that event the next major event that shaped the economy of Colorado was World War II. During WWII several military bases and plants were placed in Colorado, including Lowry Air Force Base, Denver Arms Plant, Camp Carson, Buckley Field, ENT Air Force Base, Peterson Air Field, Pueblo Ordinance Depot, Rocky Mountain Arsenal, Pueblo Air Force Base, and La Junta Army Field. Later Colorado also became the home of an Air Force Academy the Consolidated Space Operation Center, as well as Air Force and US Space Commands. As a result of the military installments Colorado's manufacturing sector grew rapidly.

Other results of the military installments in Colorado include civil space activities (NASA, the National Center on Atmospheric Research, the National Oceanic and Atmospheric Administration, and the Solar Energy Research Institute), military space activities (US and Air Force Space Commands, NORAD, and CSOC), federal laboratories (most notably the National Institute of Standards & Technology; see Appendix A for complete list), and private sector commercial activities. Leading companies that followed these activities included Martin Marietta, McDonnell Douglas, Ball Aerospace, and IBM. Contracts with the federal government also expanded the work of Colorado's research universities (University of Colorado in Boulder and Colorado Springs, and Colorado State University). These programs were important in the development of the space-related activity of the federal government,²⁰ and were also an important part of Colorado's booming economy. The Department of Defense alone contributed \$4.86 billion to Colorado's Economy in 1997.

Despite the success of Colorado's military and space industry Colorado found itself in a deep economic depression in the mid 1980s. It was at this time that economic development initiatives became an important political issue. Governor Roy Romer declared Colorado "open for business" and began to institute economic development programs to encourage technological growth within the State.²¹ These programs have helped Colorado to successfully spur high-technology growth for the past decade. However, the key to Colorado's success has been its support of a technology development network. The state has taken an active role in the process of making great ideas into great companies. Specifically, the Colorado state government functions as a intermediary, instigating state programs that coordinate the individual efforts of state government, universities, local business, and venture capital.

Colorado's Network

Local business, State universities, and State government have successfully worked together to develop a high-tech region in the Denver area. Communication and coordination between local businesses, state universities and government have played a

key role in the development of new technologies and new companies. Below is description of the roles of the important components in Colorado's technology development network. This information has been adapted from Anna Snow's work.²²

Universities

- Produce the type of graduates needed at local companies.
- At the request companies or the State of Colorado, develop curriculum geared to specific company needs.
- Provide entrepreneurship courses and promotes the "spirit" of entrepreneurship.
- Conduct research in collaboration with industry, opening labs to local companies.
- Promote technology transfer and development of upscale processes for local companies.
- Link angel capital to the start-up community.
- Help faculty members patent inventions.
- Help local companies solve real-world problems through outreach programs.
- Work closely with the Small Business Development Center.

Colorado State Government

- Focus on the physical infrastructure, housing, education, training and capital formation, and the elimination of regulatory obstacles.
- Provide State seed grants.
- Sponsor training programs under the auspices of community colleges.
- Fund strong universities and community colleges.
- Instigate non-profit incubator and venture capital organizations.
- Help graduates transition into the labor market.
- Coordinate the efforts of State government programs, universities, and local business.

State Programs

- Regional Revolving Loan Fund – Provides seed grants to assist start-ups and retain jobs through 16 regional centers.
- Customized Job Training Program – Provides customized job training for local companies.
- School to Career Partnerships – Provides job shadowing, mentorship, and work-based experience for new graduates.
- Economic Development Commission – Provides funds for infrastructure improvements, site development, and business loans.
- Small Business Development Center – Works together with Small Business Administration (SBA), College/Universities, local business development organizations, and 20 local business and counseling

centers. Conducts business research and feasibility analysis, as well as develops business plans.

- Colorado Business Assistance Center – One stop shop for services from information licensing referrals to training and assistance services.
 - Colorado Business Start up Kits
 - Colorado Leading Edge Entrepreneur Training Program – Consists of ten to fourteen weeks of intensive business training. Graduates write up a business plan articulating their ideas.
- Centers of Excellence – Located at State universities, matches funds together with industrial consortia, supports tech transfer non-profit organizations, and acts as a catalyst for worthy projects.
 - The Boulder Incubator – Non-profit corporation set up by the State to assist the development of technology-based business.
 - Assists start-ups by providing management resources and capital access, training management in entrepreneurial skills, promoting tech transfer and joint ventures, and providing a mentoring program.
 - Funded through State, fees from management services, private and public donation, and liquidity earned on equity positions held in local companies.

Venture Capital – Fund technology growth

- State of Colorado – The Boulder Incubator, Regional Revolving Loan Fund
- Angel Funds
- Local Companies
- Venture Capital Firms

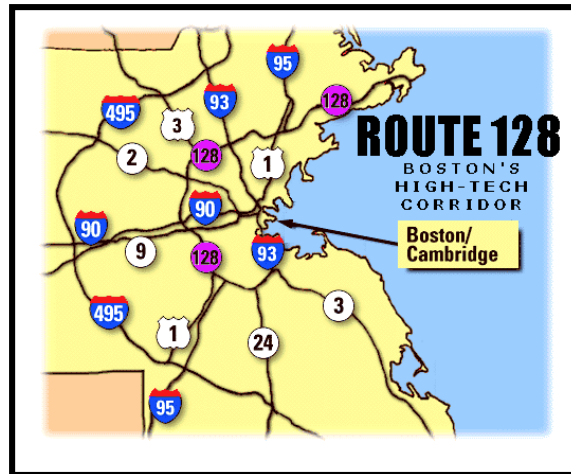
Anchor Companies - Participate in joint ventures, work closely with universities, contribute funds for development, and further develop existing technology.

Following is a list of Colorado's top technology companies (see **Appendix I** for a genealogy of Colorado's start-up companies):²³

- | | |
|-----------------------------|-----------------------------|
| 1) AT&T | 10) Ball Aerospace |
| 2) Hewlett Packard | 11) COBE Laboratories |
| 3) Lockheed Martin | 12) Sun Microsystems |
| 4) Qwest | 13) DII Group, Inc. |
| 5) Tele Tech Holdings | 14) Edwards JD & CO |
| 6) Lucent Tech, Inc. | 15) CSG Systems Intl Inc |
| 7) Storage Tek | 16) 4Front Technologies Inc |
| 8) TeleCommunications, Inc. | 17) Exabyte Corp |
| 9) IBM | |

Culture

Colorado's culture sustains a network of innovators and entrepreneurs. People in Colorado are known for being risk takers and hard workers. The business culture is open, and there is a network of angels, mentors, and investors that are willing to help entrepreneurs turn their ideas into successful companies. The network present in Colorado brings together innovators and business savvy people. The result is that Colorado maintains a leading technology center and a growing economy.

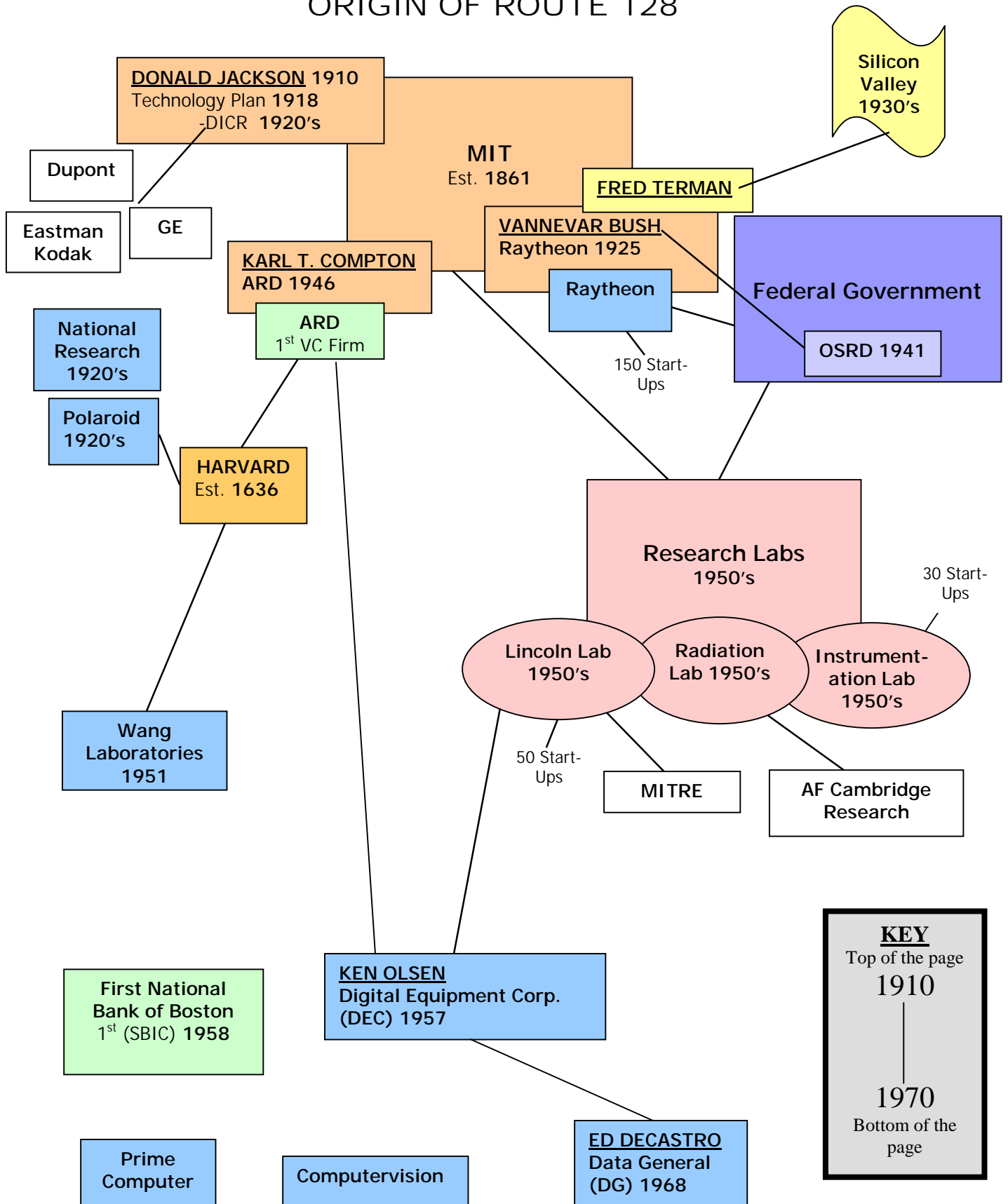


Boston's Route 128 corridor and Silicon Valley are widely considered the premier technology centers in the world. Although many of the technologies in Silicon Valley and Route 128 are months, even years old, the history of their development as high-tech centers span decades, even centuries.

Many researchers have studied, analyzed, and contrasted the development of these two centers. The following historical timeline represented in the following diagram, and narrative of the development of Route 128, based upon the first chapter of the book, *Regional Advantage: Culture and Competition in Silicon Valley and Route 128*,²⁴ by Dr. Annalee Saxenian, a professor of community and regional development at UC Berkeley. It should be duly noted that the chronological narrative of the development of Route 128 represents extensive use of Dr. Saxenian's work.

Note: Reference to "the author" in the chronology is a reference to Dr. Saxenian.

ORIGIN OF ROUTE 128



The Second World War and the ensuing Cold War recast the economic landscape of the United States. The federal government spurred the growth of new industries and regions by channeling resources to university labs to develop war-related technologies. Researchers at the Massachusetts Institute of Technology (MIT) and Stanford University as leading beneficiaries of defense and aerospace contracts, spearheaded the economic transformation of Eastern Massachusetts and Northern California. (Saxenian, 1996)

As one of the oldest industrial areas of the nation, Boston was a prime area for the development and expansion of the computer and electronics industry. The end of World War II and the beginning of the Cold War stimulated investment by the Federal Government in weapons technologies. The nineteenth century saw the formation of some of the leading technology firms in the Boston area. As Saxenian has indicated, by the 1940's the region was home to a sizeable group of electronics manufacturers. The Santa Clara Valley, by contrast, remained an agricultural region as late as the 1940's, famous primarily for its apricot and walnut orchards.

ROUTE 128

MIT was established in 1861, and, from its inception, encouraged partnership, research, and consulting with, and for, the private industry. In 1910, **Donald Jackson**, the chair of the electrical engineering department, appointed an advisory committee consisting of executives from major corporations such as General Electric (GE) and Westinghouse.

In 1918, **MIT** established a Technology Plan to encourage large corporations like **GE**, **Eastman Kodak**, and **Dupont** to financially support the university. The university also created a Division of Industrial Cooperation and Research during the 1920's to solicit corporate research contracts and inform companies of MIT research findings. The Technology Plan was discontinued in 1930, but the **DICR** (later the Office of Sponsored Projects) maintained its capacity to solicit and manage corporate contracts.

MIT encouragement of university/industry partnership also generated entrepreneurship among the faculty. Electrical Engineering professor **Vannevar Bush** helped start American Appliance Company – later the **Raytheon Manufacturing Company**. Initially founded to make refrigerators, the company changed its name to Raytheon in 1925 after acquiring the rights to a new kind of vacuum tube permitting radios to run on household current rather than on batteries. Other technology start-ups during this period included **Polaroid** – founded in 1926 by Harvard student Edwin H. Land, and the **National Research Corporation** (see **Appendix J** for anchor companies).

If the companies founded by MIT graduates and faculty formed an independent nation, the revenues produced by the companies would make that nation the 24th largest economy in the world. A 1996 study prepared by the Economics Department of BankBoston found that the 4,000 MIT-related

companies that exist today employ 1.1 million people and have annual world sales of \$232 billion. That is roughly equal to a gross domestic product of \$116 billion, which is a little less than the 1996 GDP of South Africa and more than that of Thailand.²⁵

Vannevar Bush not only started the largest company in the history of Boston (\$30 billion in revenues in 2000), but also became the principal reason the region developed as a high-tech center. Bush went to Washington to serve Roosevelt in the national defense effort and in 1941 was named the director of the newly formed **Office of Scientific Research and Development (OSRD)**, the first federal agency dedicated to science and research. In this role, Bush revolutionized the relationship between science and government by funding universities rather than government labs to pursue basic military research. He also cemented ties between **MIT and Washington** by using his friends in the local industrial and research communities to ensure that MIT graduates dominated **OSRD's** committees. MIT became the nation's leading center of research during the war, performing more research than any other US university.

The author reveals that **MIT's** laboratories received one-third of the \$330 million in contracts awarded by Bush's **OSRD** during the 1940's and 1950's. **Harvard** and Tufts also received millions of dollars for research in emerging fields such as radar, missile guidance and navigation systems, and submarine warfare. This massive government funding fueled the industrial revitalization of the New England economy.

MIT used its **OSRD** contracts to establish the **Radiation Laboratory (Rad Lab)**, the first large-scale interdisciplinary and multifunctional R&D organization at a US university.

As the author points out, local industry benefited directly from the war effort as well. **Raytheon** was awarded a stream of government contracts to produce tubes and magnetrons for radar devices. The company, tiny among the ranks of its established competitors such as GE, Westinghouse, RCA, and Bell Labs, grew dramatically through wartime military contracts. Sales grew from \$3 million to \$173 million (to equal those of GE) between 1940-1945, while employment jumped from 1,400 to 16,000. This wartime experience with high-volume production allowed Raytheon to bid successfully on missile guidance contracts during the 1950's. Raytheon is currently the manufacturer of the Tomahawk cruise missile and Patriot missile-defense system.

As the war drew to a close, the greater Boston area's so-called Research Row – composed of MIT, Harvard, other local universities, and a growing concentration of industrial laboratories – offered an intellectual and technological labor pool unsurpassed in the nation, if not the world. Interestingly enough, **Frederick Terman**, Dean of Engineering at Stanford, was a doctoral student under **Vannevar Bush** at MIT. Dr. Terman is considered by many to be the father of Silicon Valley.

The author also addresses the critical formulation of the venture capital base to support high-risk technology investments. While wealthy individuals and families had

occasionally invested in speculative technical enterprises before the war, most of Boston's capital was tied up in insurance companies and investment trusts. This began to change in 1946, when a group of New England financiers and academics, including MIT president **Karl T. Compton**, organized the American Research and Development Corporation (**ARD**) to supply capital to research-based enterprises seeking to exploit the new technologies developed during the war.

Under the leadership of **General George Doriot**, a Harvard Business School professor, ARD became the first publicly held venture capital company in the nation. Early successes of ARD-funded enterprises did, however, encourage the region's banks and insurance companies to invest in technology. The **First National Bank of Boston** formed its own investment company in 1957 and became the nation's first Small Business Investment Corporation (**SBIC**) in 1958.

The emergence of new sources of capital for technology enterprises supplemented the continued flow of government funds to local labs and universities. At the request of the Air Force, MIT established the **Lincoln Laboratory** in 1951 to develop long-range radar, air defense warning systems, and *high-speed digital data processors*. MIT's **Instrumentation Lab** (now independent Charles Storker Draper Lab), which had developed aircraft and missile navigational equipment, began developing missile guidance systems for the space race. The **MITRE Corporation**, a spin-off of MIT's Lincoln Lab, was formed as a nonprofit corporation to work on air defense and missile warning systems. The **Air Force Cambridge Research Laboratories**, which grew out of the break-up of the Rad Lab, focused on radar and air defense. By the mid 1960's these labs employed some 5,000 scientists and engineers.

The completion of the first twenty-seven mile stretch of the **Route 128** highway in 1951 created space for burgeoning research and industrial activity. Linking 20 towns in the greater Boston area, it was soon named "**America's Technology Highway**." Within a few years, Route 128 attracted a diverse mix of *research labs*, *branches of established corporations*, and *start-ups* and the highway was so congested that it was widened from six to eight lanes. By 1961, there were 169 establishments employing 24,000 people located directly on the highway. In 1965 MIT researchers counted 574 companies in the region, and the number more than doubled in the following eight years.

Branches of national corporations such as Sylvania, RCA, Honeywell, Clevite, and Avco became part of the region's growing technology complex, as did numerous distributors and professional service providers. But technology start-ups were the most important new source of industrial activity during this period. **MIT** engineering departments and research labs spawned at least 175 new enterprises during the 1960's, including 50 from Lincoln Lab and another 30 from the Instrumentation Lab. Raytheon, whose defense contracts had made it the state's largest employer, was the source of close to 150 start-ups.

These Start-ups, like the region's established electronics producers, were heavily supported by military and aerospace. Massachusetts firms received more than \$6 billion

of Department of Defense (DOD) prime contracts during the 1950's and more than \$1 billion annually during the 1960's. In 1962, federal government purchases accounted for half the sales of Route 128 firms.

It took a severe regional recession to reduce the reliance of Route 128 producers on defense and aerospace markets. As the Vietnam War ended and the space race slowed in the early 1970's, military contracts to the region fell precipitously. Close to 30,000 defense-related jobs were lost between 1970 and 1972, and the unemployment rate in the high-tech sector reached 20 percent. Many of the firms, which had grown accustomed to the low-risk, cost-plus world of defense contracting, discovered that they lacked the organization and skills to compete in civilian markets. (Saxenian, 1996)

By the time defense business rebounded in the late 1970's, its importance was overshadowed by the growth of the minicomputer industry. The minicomputer pulled Route 128 out of its downturn. **Minicomputers** accounted for 34 percent of the nation's \$26 billion computer industry in 1980.

Like other important postwar technologies, the minicomputer was developed through the combined efforts of federal military funding and university research. While basic computing was carried out at MIT in the postwar decades, the task of refining the concept for military application passed to MIT's Lincoln Laboratory, where researcher **Ken Olsen** was finding ways to make computers smaller and more versatile.

In 1957, Olsen and two partners left Lincoln Lab to start **Digital Equipment Corporation (DEC)**. The company's business plan to build electronic modules to design and test computers gained an initial investment of \$70,000 from **ARD**. In 1959 DEC introduced the Programmed Data Processor (PDP)-1, the first commercially available general-purpose computer. With a price tag of \$120,000 only 53 of these computers were sold. By 1967, however, the firm was producing low-cost minicomputers in large volumes. By 1977, with revenues exceeding one billion dollars, DEC easily led the market, with 41 percent of worldwide minicomputer sales.

Several other minicomputer firms were started in the region during the 1950s. **An Wang**, a researcher at **Harvard's Computation Lab**, started **Wang Laboratories** in 1951 to manufacture electronic calculators and word processing systems. In 1955, Minnesota-based Honeywell purchased the Computer Control Corporation, a Raytheon spin-off that pioneered minicomputer design.

The formation of computer ventures based in Massachusetts accelerated during the 1960s and 1970s. Twenty-five were started during the 1960s, compared to only six in prior years, and another 23 were founded during the 1970s. Spin-offs increased as successful firms became role models for entrepreneurs.

Ed DeCastro left DEC in 1968 to start **Data General Corporation (DG)**, the region's most publicized minicomputer start-up. DG quickly emerged as DEC's principal competitor. By 1980 it was the third-largest minicomputer company in the nation, after

DEC, and Silicon Valley-based Hewlett Packard. The region's other leading minicomputer producers, **Prime Computer** and **Computervision**, were started during the 1970s. In 1972 William Poduska left his executive position at Honeywell's minicomputer division to found Prime. Around the same time, Philippe Villers started Computervision to manufacture minicomputers as components of Computer Aided Design/Computer Aided Manufacturing (CAD/CAM) systems. Poduska and Villers each went on to start two more firms.

HOW SILICON VALLEY OVERTOOK ROUTE 128

With the best researchers, in the best institutions, developing the best technology, in a region with the most capital, the overwhelming question becomes how did Route 128 lose its supremacy as the world's leading technology center to Silicon Valley? The answer lies in one word, *culture*.

Two vastly different industrial cultures exist on each coast. Silicon Valley operates through a network of specialized companies that draws heavily on engineers trained at Berkeley and Stanford. Sun Microsystems makes Internet hardware and distributes it to Hewlett-Packard to install in its computers. Information flows freely in an interconnected web described by Saxenian as a 'decentralized system.' On Route 128, by comparison, each company stands frozen as an isolated fiefdom ruled by the traditions of hierarchy and corporate secrecy in a system of 'vertical integration.' Companies such as Digital Equipment Corporation mass-produce all the components that go into their computers--chips, disk drives--and the designs never leave the company.²⁶

Dr. Annalee Saxenian has characterized the industrial culture of Boston's Route 128 as an independent Firm-Based Industrial System, as opposed to Silicon Valley's Network-Based Industrial System. (Saxenian, 1996)

A **NETWORK-BASED INDUSTRIAL SYSTEM** is organized to adapt continuously to fast-changing markets and technologies. The system's decentralization encourages the pursuit of multiple technical opportunities through spontaneous regroupings of skill, technology, and capital. Its production networks promote a process of collective technological learning that reduces the distinctions between large and small firms and between industries and sectors.

Silicon Valley's network-based industrial system promotes collective learning and a flexible adjustment among specialist producers of a complex of related technologies. The region's dense social networks and open labor markets encourage experimentation and entrepreneurship. Companies compete intensely while at the same time learning from one another about changing markets and technologies through informal communication and collaborative practices; and loosely linked team structures encourage horizontal communication. Dense networks of social relations play an

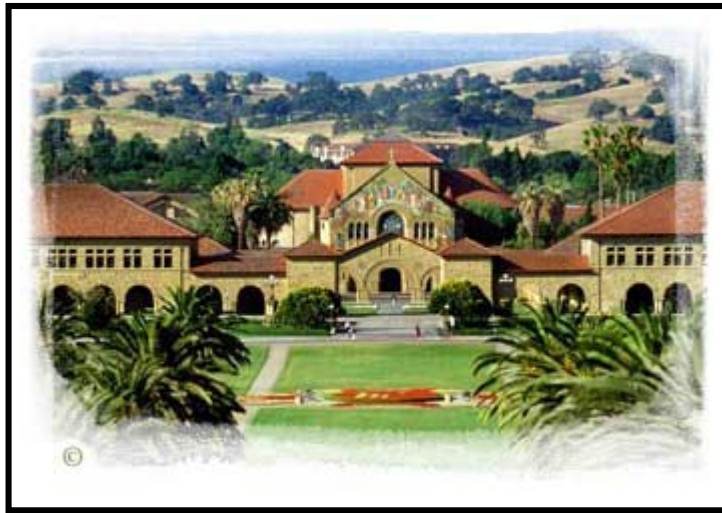
important role in integrating the firms in Silicon Valley's fragmented industrial structure.

An **INDEPENDENT FIRM-BASED INDUSTRIAL SYSTEM** flourishes in an environment of market stability and slow-changing technologies because its leading producers benefit from the advantages of scale economies and market control. It is overwhelmed, however, by changing competitive conditions. Corporations that invest in dedicated equipment and specialized workers find themselves locked in obsolete technologies and markets, while hierarchical structures limit their ability to adapt quickly as conditions change. Their inward focus and vertical integration also limit the development of a sophisticated local infrastructure, leaving the entire region vulnerable when large firms falter.

Boston's industrial system is based on independent firms that internalize a wide range of product activities. Practices of secrecy and corporate loyalty govern relations between firms and their customers, suppliers, and competitors, reinforcing a regional culture that encourages stability and self-reliance. Corporate hierarchies ensure that authority remains centralized and information tends to flow vertically. The boundaries between and within firms and between firms, as well as local institutions thus remain far more distinct in this independent firm-based system.

An analysis of the contrasting developments of the Route 128 and Silicon Valley result in three very powerful implications for the State of Utah:

- 1) In both cases, a visionary at the university level initiated collaboration between the university, the high-tech industry, and the general business community. The visionaries also encouraged entrepreneurship among their students and provided resources for the development of start-ups.
- 2) The foundation of an effective technology development or innovation system is a strong university-industry relationship. If universities are closed or are unable to attract industry partnership, the system breaks down.
- 3) Having the world's best universities, technologies, researchers, and capital base is not sufficient enough to become the world's leading high-tech center. The labor force culture (not risk averse, 9 vs. 18 hour work days, job mobility), intra-organizational culture (meritocracy, hierarchy, innovative, open), and industrial culture (collaboration and openness between firms) dictate how effective the system will be in generating innovative technologies and developing companies.
- 4) The development of Route 128 would be very difficult to duplicate, as it spanned over a century and was heavily subsidized by the federal government. The impetus for Route 128 was ultimately World War II and the Cold War.



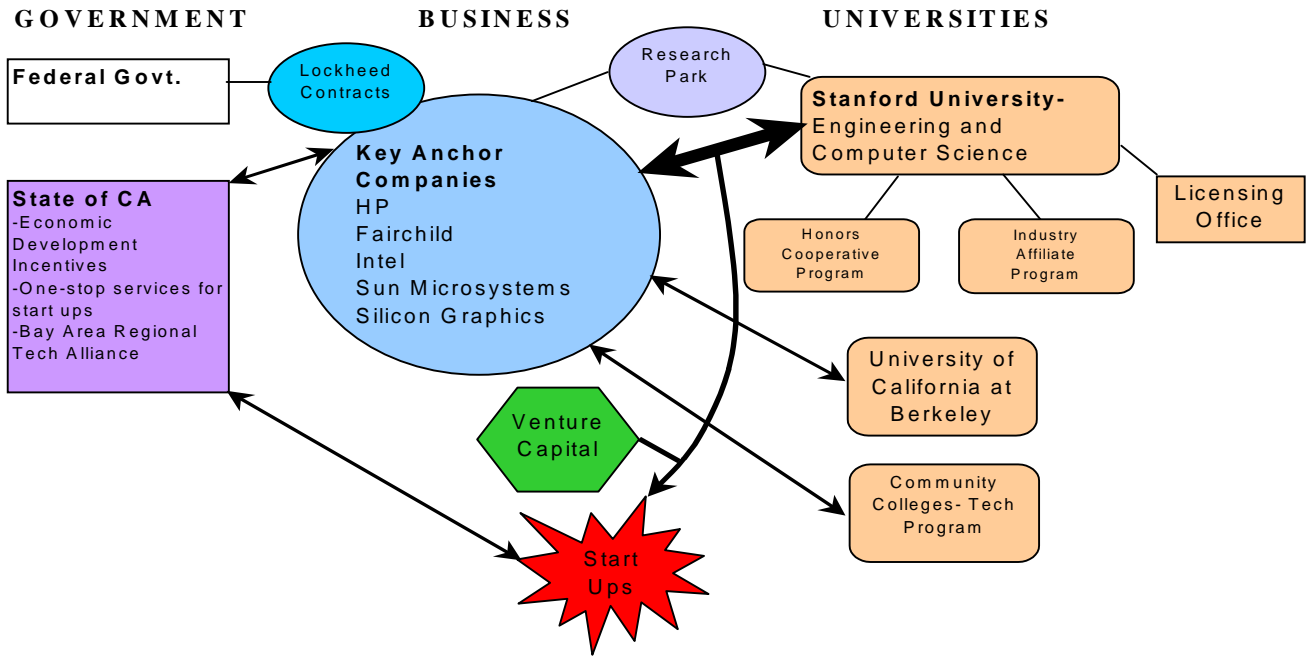
SILICON VALLEY

Silicon Valley's habitat specializes in breeding companies....What sets Silicon Valley apart are not the technologies discovered there, but the companies in the region that develop, market, and exploit these technologies. In other words, the Silicon Valley story is predominantly one of the development of technology and its market applications by firms—especially by start-ups.²⁷

The following chronology of the development of Silicon Valley is based upon the article *Silicon Valley and Route 128: Two Faces of the American Technopolis*, by Paul Mackun.²⁸ References to Saxenian, Rogers, and Larsen are cited in Mackun's article.

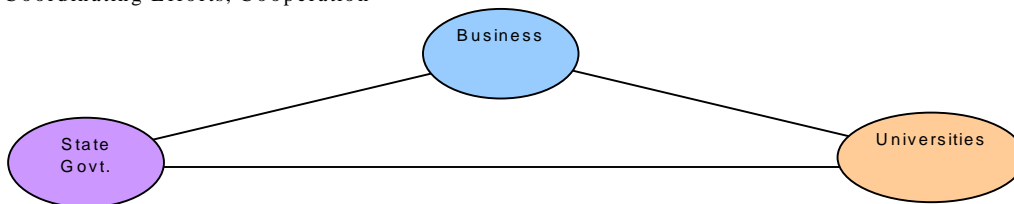
Geographically, Silicon Valley is an area of Northern California composed of a thirty-mile by ten-mile strip of land in Santa Clara County between the cities of San Francisco and San Jose. This economic region begins in the Northwest of the Valley in Palo Alto, where the bulk of theoretical and practical technological research in the area occurs at Stanford University and the Stanford University Research Park. Traveling to the southeast, one finds the bulk of semiconductor firms ensconced in communities such as Sunnyvale, Cupertino, and Mountain View.

Silicon Valley Technology Development



Bay Area Consortiums

Coordinating Efforts, Cooperation



Until the middle of this century, this agriculturally rich region of Northern California was better known for its apricots and walnuts than for its Apples. Even at the end of World War II, the predominant industry around San Jose was small-scale food processing and distribution. A combination of regional advantages and historical accidents conspired to produce one of the greatest "science parks" in the world. Observers have identified the following regional advantages: world-class academic institutions (**Stanford University** and the **University of California at Berkeley**), brilliant scientists, military procurements of semiconductors and the pleasant climate of Northern California.

Many people have attributed the success of the Valley primarily to the influence of nearby institutions of higher education, particularly Stanford University. In the 1920s, administrators at Stanford sought to improve the prestige of their institution by hiring highly respected faculty members from East Coast universities. One important recruit was **Fred Terman**, an electrical engineer from MIT. Like many of his colleagues, he performed cutting-edge research in electronics. Unlike many other members of the faculty, though, he encouraged his students to sell applications of these new-technologies into the marketplace. By providing funds and equipment, Terman enabled two of his first recruits, **David Hewlett and William Packard**, to commercialize the audio-oscillator in the late 1930s. After selling their first oscillators to Disney Corporation, they reinvested their earnings and expanded both their product line and their range of customers.

In 1950, twelve years after its founding, **Hewlett-Packard** employed 200 people and sold 70 different products, with sales of over \$2 million. It pioneered the formation of a distinctive Silicon Valley management style, treating workers as family members. Numerous workers have sought to duplicate Hewlett-Packard's management style. In 1954, they accepted an offer by Stanford University to rent part of **Stanford Research Park** for their operations. This began the agglomeration of industry in Palo Alto, as many other firms subsequently rented other plots of land to take advantage of proximity to the university. Stanford Research Park, through the efforts of a few influential professors and university administrators, became the nucleus of the budding Silicon Valley. By the 1980s, the entire park had been rented out to local firms.

The 1950s also witnessed the birth of the semiconductor industry. Again, the efforts of one individual stand out. **Dr. William Shockley**, a Cal Tech trained engineer, revolutionized electronics by developing the transistor to magnify electronic images and replace much bulkier, energy-wasting vacuum tubes. Shockley, along with a number of talented young scholars from the East Coast, formed Shockley Industries in Palo Alto, one of 20 companies that sought to manufacture transistor technology. Unfortunately, his stubbornness and lack of tact soon alienated many of his colleagues, causing them to resign from his firm and form their own company, **Fairchild Semiconductor Corporation**. Fairchild became the first firm to manufacture exclusively in silicon and rapidly developed into one of the largest firms in the California electronics industry. Rogers and Larsen estimate that more than 70 high-tech

companies are direct or indirect descendants of the Fairchild Corporation (see **Appendix K**).

The role of government, along with the natural environment of Northern California, cannot be underestimated. The relocation of major military contractor **Lockheed** in 1956 brought federal defense dollars to the area. Semiconductor procurements by defense agencies amounted to approximately two-fifths of total production. Pleasant climate and availability of space were other important factors in attracting individuals and firms to Silicon Valley and retaining them thereafter. A survey of Silicon Valley companies disclosed that more than two-thirds of corporations rate the area's amenities and climate as outstanding. The presence of major research universities and the concentration of high-trained workers also ranked high (Rogers and Larsen 1984).

This rapid rise of technology reflects itself in the organization of Silicon Valley. Those who founded or were employed by these new firms considered themselves to be technological trailblazers and the formal and informal "communities" that they developed are in some ways akin to the pioneers who settled the West in the 19th century. Residents of this technological society were, originally at least, a strongly homogenous group: white, male, Stanford or MIT educated engineers who migrated to California from other regions of the country. As modern-day pioneers, they were especially responsive to risky ventures that had the potential for great rewards. Saxenian notes, "Silicon Valley's heroes are the successful entrepreneurs who have taken aggressive professional and technical risks: the garage tinkerers who created successful companies."

Along with sharing risks, entrepreneurs also shared a camaraderie unsurpassed almost anywhere else in American industry. Even engineers and scientists who work at competing firms during the workday remained close friends off the job. According to an account by Tom Wolfe, the manager of one semiconductor firm would not hesitate to call a competitor for assistance on technical matters. After work, the engineers and programmers would meet at popular drinking establishments in the Valley to share high-tech "war stories." These after-hours discussions enabled them to share industry gossip as well as facilitate employment searches in the region.

Job mobility statistics illustrate the success of these networks; the average turnover rate for small-to-medium sized firms was 35 percent and the average job tenure (in the 1980s) was approximately two years. Geography probably played as critical role in this rate as did informal social contacts. The spatial concentration of a large number of technology-based firms enabled people to change employers without altering other aspects of their lives. When a person left one firm in Palo Alto for another, there was no need to move one's residence or take one's kids out of a particular school district to enter a different firm. The attitude of the Valley served as a catalyst for risk-taking. In many cases, a small group of employees in a firm dissatisfied with their current place of employment would gather together after work to tinker around with some of their own ideas. They would then develop a business plan, acquire funds from venture capitalists, and seek advice from local academic sources. If they succeeded they were heroes. If

they failed, many employers were located in the same town or in a neighboring community.

As people in the region became occupationally mobile, their roles became interchangeable: employers became employees and co-workers have the ability to become competitors. This resulted in engineers developing strong loyalties to technology, as well as fellow engineers and scientists, and thus possessing far less allegiance to a single firm. Although it may seem paradoxical that such cooperation would occur under such obviously competitive circumstances, Saxenian notes the motto of the region, " competition demands continuous innovation, which in turn requires cooperation among firms."

Rapid flows of practical information became the currency of choice. Applied scientific research was constantly reworked to develop market goods. It is not surprising that rapid changes led to industrial diversification and contributed to the flexibility and resilience of the economic region (See **Appendix L** Silicon Valley Microclusters). The lack of rigid hierarchies also extended to the firms themselves. The traditional delineations between employers and employees were not as sharp as on the East Coast, and in some cases they disappeared entirely. Beginning with Hewlett and Packard, many Silicon Valley companies sought a much more interactive environment between employers and employees. Decentralization of powers followed as major divisions of firms were given a large amount of autonomy.

In short, Silicon Valley has a regional-based industrial system - that is, it promotes collective learning and flexible adjustment among companies that make specialty products within a broad range of related technologies. The region's dense social networks and relatively open labor markets encourage entrepreneurship and experimentation.²⁹

THE ROLE OF STANFORD

Stanford, a critical player in the development of Silicon Valley, has changed the way universities are viewed. Whereas most universities produce great students, Stanford produces great students *and* great companies, as seen in **Appendix M** and **N**.

It is almost impossible to name a leading-edge company in Silicon Valley that isn't closely associated with Stanford: \$4.1 billion Cisco Systems, \$2.9 billion Silicon Graphics, and \$7.1 billion Sun Microsystems were all started by Stanford professors or administrators. Such new kids on the block as Netscape Communications and Rambus also have close ties to the university.³⁰

Over the years Stanford has fostered strong relationships with major industry participants. The collaboration between industry and academics, and entrepreneurial spirit of students and faculty has produced a technology development system

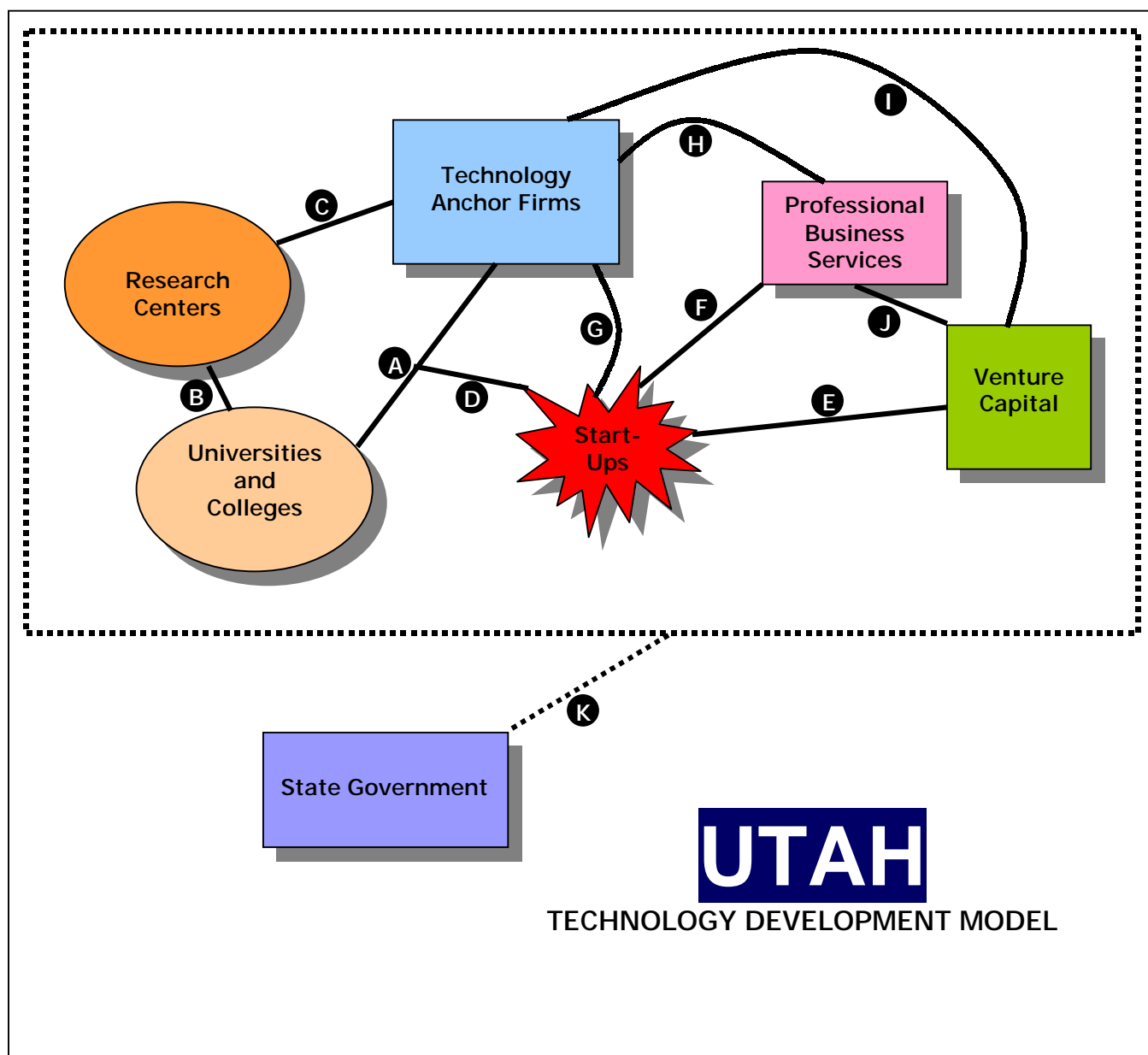
unmatched anywhere in the world. Specifically, many programs at Stanford were formed to serve and develop relationships with industry:

- Honors Cooperative Program – Educates employees of local companies on campus.
- Tutored Videotape Instruction Program – Educates employees via television.
- Industrial Affiliates Program – Promotes collaboration on research and investment by local companies.

UTAH TECHNOLOGY DEVELOPMENT MODEL

Based upon an in-depth analysis of the Austin, Colorado, Route 128, and Silicon Valley case studies, as well as extensive research of prominent academic sources, we devised an ideal model for technology development within the State of Utah. The Utah Technology Development Model is represented in **Figure 1**. In this section, a brief description of the different components is given, followed by a theoretical characterization of the roles and functions of each of the components within the model. Anecdotal evidence derived from our case analyses is also cited. The final sections of this report: Utah Strengths and Weaknesses, Role of the State Government, and Recommendations, are based upon the model below.

Figure 1



COMPONENT DEFINITIONS AND SYSTEM FUNCTIONS

UNIVERSITIES AND COLLEGES



Universities and Colleges represent the critical infrastructure of high-technology development; **research universities** and technically oriented colleges are principal to this process. A “research university” is a university whose primary missions emphasize (1) the process of conducting research, and (2) the training of graduate students in how to conduct research.³¹ Research universities drive innovation as they train engineers, computer programmers, and managers who make up the pool of entrepreneurs and professionals that will likely seed future companies. Theoretically, the university serves to catalyze informal networking among students and faculty.³²

*MIT is one of the leading research universities in the country. In 1998-99, approximately 2,568 researchers worked with faculty and students on projects funded by government, foundations, and industry. MIT employs 2,401 research assistants and 706 teaching assistants. A recent study concluded that university inventions add more than \$20 billion and 150,000 jobs to the U.S. economy every year. MIT routinely leads all U.S. universities in patents granted and last year signed 68 license agreements with private companies.*³³

Appendix O shows MIT’s research sponsorship for 1999. Universities are most effective at spurring economic growth when they aggressively implement technology transfer. Universities that are relatively more effective in **technology transfer** are characterized by (1) higher average faculty salaries, (2) a larger number of staff for technology licensing, (3) a higher value of private gifts, grants and contracts, and (4) more R&D funding from industry and federal sources.³⁴ In this realm, there is a strong correlation between university scale and innovative capacity exists (Rogers et. al, 2000); larger universities exhibit economies of scale in terms of federal research obligations, industrial R&D support, licensing revenue from inventions, and private endowments³⁵.

Since its inception, Stanford University has spawned a significant number of world-class companies, most notably Hewlett-Packard, Fairchild Semiconductor, Apple Computer, Cisco, Sun Microsystems and Silicon Graphics. Stanford’s “Wellspring of Innovation” project estimates that one-fourth of the top 150 public companies in Silicon Valley were “Stanford-founded.” Aggregate revenues for Stanford-founded companies in 1999 totaled more than \$90 billion, roughly 40 percent of the total for the top Silicon Valley firms.³⁶ Stanford’s unparalleled contribution to Silicon’s Valley’s development can be traced to a number of sources including a unique group of faculty, staff and students that are entrepreneurial driven.³⁷

A university-related **research park** or technology incubator constitutes a property-based venture that has dedicated land and buildings, designed primarily for private and public research and development facilities, high technology and science based

companies, and support services.³⁸ Technology incubators generally provide all of the services needed to turn an innovation into a viable business. This includes professional assistance, access to venture capital, consulting services, and low-rent office space and equipment. Benefits for firms include university-industrial affiliation and employee development opportunities. Benefits to the university include licensing revenue and graduate job placement opportunities.

RESEARCH CENTERS



Research Centers include corporate research institutes, government-funded laboratories, and research consortia, which can be spontaneous private organizations, publicly spurred associations, or joint ventures. These institutions perform intensive basic research, much of which is published in academic journals and white papers; as this knowledge accumulates and spurs innovation broadly. Research centers tend to draw the participation of outside firms, obtain federal R&D money, and develop fruitful relationships with universities; the likely result of such concentrated research talent, and close relationships among universities, corporate interests, and government experts, is the dissemination of technology know-how, the seeding of start-ups, and the advancement of large firm R&D efforts.

VENTURE CAPITAL



Venture Capital includes angel investing, professionally managed venture funds, university-related financial backing, state-managed start-up funds, and other forms of equity finance. Wealthy individuals, investment bankers, and professional venture capitalists are all involved in new venture underwriting and financing. Venture capitalists have recently emerged as important gatekeepers in the innovation cycle. They can provide seed funding, and second- and third-round financing for new technology ventures. VC's can also serve an "incubator" function, transmitting important expertise to entrepreneurs; such expertise includes management experience and access to a network of professional connections. As the venture grows, VCs impart vital strategic information to new businesses. However, the principal role of the venture capitalist is to provide the funds necessary to grow the enterprise into a sizable business and eventually position it to undertake an initial public stock offering or be acquired by another company.³⁹

PROFESSIONAL BUSINESS SERVICES



Professional Business Services include specialty lawyers, accountants, headhunters, and business constants. A sophisticated service infrastructure allows start up firms to focus on their core competencies, rather than dissipate their energies across a broad range of peripheral or supporting activities. Contract manufacturing services are available to develop prototypes, or engage in high volume or "peak load"

manufacturing of sub-systems and finished goods. Specialized public relations firms provide guidance on, and assistance with, press and analyst relations and associated collateral, strategic positioning, mediators, trade shows, and other important events. Accounting firms have specialized high-technology practices and services designed for start-up and high-technology companies.

Start-up and maturing firms in order to augment management teams and recruit new talent use executive search firms extensively. Real estate firms have expertise in the provision of facilities, especially designed for high-technology firms. For example, some firms may require clean rooms or highly purified water supplies; others set out to create a “campus”-like environment for their professional employees. Law firms that specialize in high-technology law also play a crucial role in the creation of new ventures. In addition to litigation, they perform several major functions, including: initial incorporation, company name search, stock allocations, patent filings, alliance agreements, public offerings prospectus, SEC filings, and acquisition agreements. Senior partners typically forge long-standing relationships with the venture capital community and often refer entrepreneurs to VC’s. In sum, the function of this supporting infrastructure is the timely provision of a wide range of specialized expertise so that companies can grow quickly and effectively.⁴⁰

TECHNOLOGY ANCHOR FIRMS



Anchor Firms are large industrial firms that produce an agglomeration effect. That is, they possess resources that are attractive to other firms—typically suppliers, customers, and strategic partners. This clustering effect eventually leads to a “critical mass” of companies, and desirable scale economies result (see Appendix). Anchor firms spend large sums on R&D for the sole purpose of commercialization. These firms not only excel in innovation, but they also have sufficient “complementary assets” to bring products to market and thereby reap economic rewards that smaller firms frequently do not. For most developed high-tech economies, anchor firms exceed a billion dollars in annual revenues. Increasingly, large industrial firms are diversifying their efforts by spinning off business divisions into independently managed daughter firms and “spinning in” innovative start-ups in order to hedge against disruptive technologies. Because anchor firms are so large, their fortunes can bear heavily on the success or failure of a regional technology economy.

START-UPS



Start-ups⁴¹ are both the end product of technology development and the driver of economic growth. Start-ups are frequently spun off by anchor firms, research centers, and universities, or they may be formed by technology enthusiasts bent on profiting from their ideas. Yet another type of new high-tech firm can be best described as a “re-start.” These are typically ventures that are either acquired by larger firms or are venture-backed start-ups whose business models need recalibration under new

management teams. Some may be able to rise out of the ashes of the failing parent or be bought out to achieve independent viability. A further source of new enterprises is that of researchers/scientists wishing to commercialize their ideas.

In the ideal model, significant fluidity exists between the various components of the ecosystems. Executives move from high-tech companies into venture capital, investment banking, consulting—among others—and the movement may be the other direction as well. Engineers change jobs with much frequency and may move from one firm to another “just down the road.” As one would expect, many start-ups result in bankruptcy, rather than “failure.” Defunct firms frequently seed new ventures as was the case when Word Perfect closed its doors in Provo. A small percentage of new ventures may grow rapidly into anchor firms that can drive regional economic growth. Because new technology ventures are more risky—they generally lack collateral and are based solely on an idea. Thus, start-ups have difficulty obtaining funding from conventional sources. Adequate seed capital and larger sums designed for second- and third-round financing are essential for high-technology start-up growth and exit strategies. In sum, start-ups heavily depend on resources external to the firm. The essential inputs, then, for generating dynamic start-up activity—“flexible recycling”—are research universities, anchor firms, and a significant amount of venture capital.

STATE GOVERNMENT



State Government⁴² can do much through institutionalized economic development efforts including R&D incentives, tax abatements, and incubation entities. Strategic economic development efforts can touch every aspect of the technology ecosystem.

Since the depression era, when economic necessity dictated favorable treatment and concessions for business interests, in return for their continued efficacy, economic developers have employed supply-side strategies. These include modest attempts to stimulate economic growth through loosely tailoring tax and labor policies to create an amiable business milieu. Governments may elect to induce business relocation through lower taxes and fiscal exemptions, as well as through capital subsidies and discounted land.

According to the ideal model, government action should be diffuse and stop short of direct intervention into otherwise free markets. A mix of chambers of commerce, quasi-public corporations, and perhaps industrial development corporations should collectively assist in cultivating investment and innovation. Such an approach contains the benefit of decentralizing government control and ostensibly precludes overt market distortions.

Several shortcomings of supply-side tactics have led to an increasing use of demand-side concepts. It remains unclear whether the economic benefits of employment and firm revenue spillover into other parts of the economy, and thereby generate more jobs and profits for proximate firms and people. In other words, difficulty exists in

measuring whether fiscal incentives are really worth their cost in lost tax revenues despite the multiplier effect of a relocating firm. Further, supply side enterprise zones, which provide lower taxes to firms that locate and invest in depressed regions, frequently become obsolete. As soon as one locality creates tax incentives for firms, another proximate locality likely will match or better it. This phenomenon occurs at the state and local level and often nullifies any comparative advantage of location.

Because of such uncertainties, states have studied and implemented more aggressive entrepreneurial policies for pumping up economic growth. Rather than trying to entice and induce capital and firms to relocate, demand-side policies actually augment capital formation, the creation of firms, and the development of new productive capacities. Instead of merely shifting capital, demand-side policies seek to create it. Supply-side policy architects begin with the assumption that successful exporting—capturing and creating new markets—best provides new employment to state citizens while infusing the local state economy with exogenous income. This infusion of new capital, then, spurs demand for local goods and services. Ultimately, state and local governments benefit by taxing this income at multiple levels, both when firms earn it and when employees spend it.

Demand-side policies tend to focus on innovation and high-technology incubation. Instead of merely “chasing smoke stack industries,” states have given greater attention to “product development, technology transfer, capital formation, and industrial innovation.”⁴³ The research of David Birch at MIT has reinforced *the innovation orientation by establishing that small businesses produce an economic multiplier, especially in employment, greater than large firms*. Moreover, he argues, the mere inducement of large firms provides very few new jobs, especially since large firms tend to transfer key employees from exogenous locations. The belief that small business success provides the key to regional prosperity has increasingly justified the use of public resources in creative ways including venture capital and high-tech development. By creating a congenial environment for high-tech start-up firms and other small businesses, government effectively combines the risk bearing might of the state with management expertise and vision of small business.

UTAH TECHNOLOGY DEVELOPMENT ENVIRONMENT

UNIVERSITIES AND COLLEGES

The mission of Stanford University's Office of Technology Licensing (OTL) "is to promote the transfer of Stanford technology for society's use and benefit while generating unrestricted income to support research and education." In 1997, the Stanford University Office of Technology Licensing (OTL) earned an income of \$52 million from license income, equivalent to 13 percent of the University's total sponsored research expenditures. The OTL staff of 19 employees handled 248 invention disclosures, filed 128 new patents, licensed 15 start-up companies, managed 272 licensed technologies that yielded income in 1997, and reported over 1,044 active technology licenses.⁴⁴

In contrast, in 2000, University of Utah received 187 invention disclosures and filed 123 patents, at a rate of 66 percent. Utah State University received 48 disclosures and filed approximately 13 patents, at a rate of 27 percent. This reflects a difference in philosophy between Stanford and the two Utah universities, whereby Stanford takes a less conservative approach to patent filing while Utah's universities put significant time and resources into determining which technologies to patent, often due to smaller OTL funding levels at Utah's universities comparatively.

While smaller in scale, Utah's two major government funded research universities, University of Utah, with over \$600 million in sales and 6,000 jobs created from companies that originated from its R&D endeavors, and Utah State University, which received over \$125 million in research grants last year, making it No. 1 in the nation in the amount of research dollars generated per faculty member, have well established and widely known research institutes in their respective disciplines such as biotechnology, engineering, software development and aerospace technology. **Appendices P and Appendix Q** provide a brief synopsis of the R&D programs and activities at University of Utah and Utah State University.

While Utah's institutions of higher learning have ranked very well in sciences and engineering, according to National Academy of Science rankings; the University of Utah ranked 33rd in computer science, 10th in biomedical engineering, 53rd in chemical engineering, and 53rd in electrical engineering; while Utah State University ranked 47th in civil engineering, they often lack the established relationships with industry that promote technology development and entrepreneurship. By further strengthening their business focus, University of Utah and Utah State University have the foundation and potential to develop into research entities similar to Stanford's, playing an inimitable role in driving the economy of the Wasatch Front corridor.

TECHNOLOGY ANCHOR FIRMS

Anchor companies are innovative companies that have sufficient “complementary assets” to commercialize new technologies. Under this definition there is only one anchor firm located in Utah - Novell. Novell had revenues over \$1 billion in the year 2000 and was among the leaders in producing newly patented technology. This should be a source of concern for the State, since growth occurs around a clustering of spatially and intellectually proximate companies. Companies drive each other to innovate while the employees network one with another to develop specialized knowledge and skills.

There are many other technology companies located in Utah that either have the *potential* to become anchor firms or currently play the role of an anchor firm in some small way. Below is a list of these companies. Some of these companies are headquartered in Utah, while others are branch offices of major technology firms. All of these companies have research and development operations in Utah, which is necessary for instigating innovation and potentially creating spin offs. Smaller companies have been included in this list because either significant portions of their R&D operations are located in Utah, they are headquartered in Utah, they are currently experiencing rapid growth, or their technology is considered to be up and coming. All of the companies have at least 200 employees. See (**Appendix R**) for the contact information and URL address of each company.

- 1) Ballard Medical Products – Specialized medical products
- 2) Bourns – Electronic network resistors, sensors and controls, R&D
- 3) Epixtech – Software for automated library systems
- 4) Evan & Sutherland – Computer graphic systems
- 5) GE OEC Medical Systems – Medical imaging and information solutions
- 6) Gentner – Conferencing products, software and hardware
- 7) Ingenix - Health data and information, software and service
- 8) Intel Research & Development Center – Microprocessors, HR and R&D
- 9) Iomega – Data storage devices (relocating headquarters)
- 10) L3 Communications Corporation - Secure and specialized systems for satellite, avionics, and marine communications
- 11) Merit Medical Systems – Disposal medical products
- 12) Myriad Genetics - Gene mapping, family history analysis, and protein interaction identification
- 13) Novell – Networking software
- 14) PowerQuest – Software for partition and file management systems tools
- 15) Sonic Innovations – Hearing aids, digital signal processing (DSP) technology
- 16) Utah Medical Products – Medical product development and manufacturing
- 17) Unisys Corporation – Unix solutions, Development of eBusiness software
- 18) Zevex International – Medical products development and manufacturing

This list is derived from analysis based upon a company’s financial information, number of employees, growth, location, type of technology, research and development

capabilities, and other factors derived this list. Most of these companies fall into three broad categories: **software**, **biotech**, and **specialized computer hardware systems**, since this is where Utah's relative strengths lie and there is a significant presence of innovation in these areas. Existing companies within these industries have the potential to develop into world leading high-technology industry cluster in Utah.

Looking at strictly new technology creation, which can be observed by the number of patents, the following companies were the "innovators" in the State of Utah for the years 1995-1999. This list does not identify the success of the commercialization process of new technology; it simply gives the number of patents for each company. It does, however, reveal that companies are developing new technologies and therefore identifies companies with significant research and development operations in Utah. See (**Appendix S**) for a complete listing of number patents in Utah from 1995-1999

MORTON INTERNATIONAL, INC. UNIVERSITY OF UTAH RESEARCH FOUNDATION IOMEGA CORPORATION BECTON, DICKINSON AND COMPANY BAKER HUGHES INCORPORATED MORTON THIOKOL, INC. AUTOLIV ASP, INC. ULTRADENT PRODUCTS, INC. CERAMATEC, INC. UNIVERSITY OF UTAH UNISYS CORPORATION	MERIT MEDICAL SYSTEMS, INC. EVANS & SUTHERLAND COMPUTER CORP. SARCOS, INC. SARCOS GROUP SPECIALIZED HEALTH PRODUCTS, INC. THERATECH INC. MYRIAD GENETICS, INC. LIFETIME PRODUCTS, INC. NOVELL, INC
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RESEARCH CENTERS

University of Utah Research Park

By 1969 the Utah State Legislature had authorized the development of a research park modeled after the Stanford Research Park. The Research Park constitutes the origins of Utah's high-tech industry and significantly facilitates technology transfer from the University to the private sector.

The Research Park has steadily grown since 1972, when construction began. Today, the park hosts some of Utah's most prominent homegrown technology firms: Evans & Sutherland, Myriad Genetics, NPS Pharmaceuticals, TheraTech, and ARUP. In addition, the renowned Huntsman Cancer Institute is also located on University of Utah's campus, along with Intermountain Health Care facilities.⁴⁵ These facilities have brought out of state investment to the university. Annual in-state production of Research Park residents now exceeds \$500 million, representing a payroll of approximately \$225 million for the site's 5,500 employees, over half of which are employed by firms that stem from university origins.⁴⁶

In selecting occupants, the University considers whether beneficial relationships are likely to develop between the University and the company. A 1998 survey of Research

Park companies showed that 81 percent of companies use faculty as consultants. Over 60 percent contribute financially to the University. Nearly 60 percent report participation in joint research proposals, and 85 percent use faculty or students in research activities. Many companies also allow University departments to use specialized research equipment, and several encourage continuing education by offering to pay tuition and related costs for employees. All respondents report the Research Park location and access to faculty as assets to their business.⁴⁷

Utah State University Research and Technology Park

The Utah State University Research and Technology Park began operation in 1986, with a mission of providing an environment with facilities, technology, services, programs and expertise that stimulate and support the creation and growth of research and technology-based enterprises. The Utah State University Research and Technology Park houses private and public sector tenants who are primarily engaged in research and technology-oriented activities. The University also operates a technology-based Business Incubator within the park. Tenant collaboration with Utah State University for research and technology development is strongly encouraged and supported in this process.

Currently, the park has 12 buildings with a combined total of 264,260 square feet of space, housing approximately 35 companies.⁴⁸ These include:

- Convergys
- Earthfax Development
- Juniper Systems
- Letterpress Software, Inc.
- Open Net
- Siemens Electronic Design Solutions and Services
- Sorenson Media
- TeraGlobal Communications
- Terra Star, Inc.
- USU Space Dynamics Science Group

The University of Utah and Utah State University maintain departmental programs and laboratories in specialized areas of biotechnology, computer science, laser technology, aerospace, and others. Many of these centers, such as the Huntsman Cancer Institute are nationally if not world-renown. Promoting the development of these centers and encouraging the involvement of industry, venture capital, and entrepreneurs in developing and commercializing research is the current and future epicenter of Utah's high-tech growth.

START-UPS

The 2000 Development Report Card by the Corporation for Enterprise Development⁴⁹ reveals the strengths and challenges of Utah's technology development and company creation system.

Utah does well on entrepreneurial measures such as new company formation. Utah ranked 15th overall with 297 new firm births. Utah was also ranked well on measures of new job creation from start-ups. The State efficiently commercializes technology and forms companies with the small amount of resources available. Also, Utah does well in terms of patent creation but still lags behind other major high-tech centers in developing successful start-ups (see **Appendix T**).

One of the important implications of the productivity analysis of Utah's high-tech companies is that *the region or industrial system in which a company operates affects the productivity of that company*. In other words, unless an effective industrial system is developed, a company cannot realize its full potential. Other indicators also validate this notion.

The productivity numbers in the introduction portion of the report show that Utah's high-tech companies, on average, are not as productive as their counterparts in Silicon Valley, Austin, Denver, and Boston. Utah is ranked 36th in Business Closings with a score of 15.41.⁵⁰ This is an important ranking because the most basic indicator of the competitiveness of the businesses in a state is whether or not businesses

survive. This evidence suggests that Utah's technology development and innovation system does not tend to produce the quality of start-ups and technologies that become anchor companies in their respective industries; as start-ups that do survive are often acquired.

Utah's main incubator-like organizations include the Centers of Excellence and the Economic Development Corporation. These organizations could be further developed as well as additional non-profit incubators that provide capital, services, and training for start-ups.

Evans and Sutherland gave birth to Silicon Graphics (Jim Clark), Pixar (Edwin Catmull), and Adobe (John Warnock). Novell gave birth to US Web and BEA Systems. There is a long list of companies that could have been headquartered here but aren't. Some people say it is because Utah lacked infrastructure but I disagree. The Silicon Valley lacked infrastructure too just 10 or 15 years ago. Wilson Sonsini only had 10 employees in 1985. The problem is that the key stakeholders in the venture ecosystem in Utah are not aligned and connected like they are in other regions. The VCs need to be tighter with the Universities, entrepreneurs need to be more abundant with their equity and savvy to good capital structures, and entrepreneurs who understand the process need to mentor the first timers. The Utah State retirement funds need to be investing in Utah venture funds like Calipers in California.

A Local Venture Capitalist

VENTURE CAPITAL

Utah needs more venture capital to fund innovation. The amount of venture capital in the state is growing but available venture capital is still a roadblock to greater commercial success of Utah start-ups (see **Appendix U**). Utah's venture capital and private equity deployed rose from \$419 million in 1999 to \$1.017 billion in 2001.⁵¹ This is an increase of more than 100 percent. In comparing Utah's venture capital with other high-tech states, it is clear that Utah trails behind. Utah was recently ranked 19th in the venture capital, compared to Gross State Product. Other states with high-tech centers were ranked much higher; California was ranked 1st, Massachusetts was ranked 2nd, Texas was ranked 3rd, and Colorado 4th.⁵² Besides the lack of venture capital funds, another problem is that Utah's venture capital companies more closely resemble seed funds and often do not provide larger amounts of capital needed for high-growth start-ups. Following is a list of venture capital companies:

1. Canopy Group: \$0.05-\$1 million
2. Cornerstone Capital Group: \$3-\$7 million
3. Granite Capital Partners: \$2-\$10 million
4. New Media Venture Partners: \$1-\$2 million
5. Peterson Ventures: \$0.5-\$10 million
6. Utah Ventures: Up to \$6 million
7. vSpring: \$0.5-\$4 million
8. Wasatch Venture Fund: \$0.25-\$1 million

PROFESSIONAL BUSINESS SERVICES

Which comes first, successful start-ups or professional business services that help start-ups successfully maneuver through the commercialization process? The problem is that start-ups need a network of professional business services to grow their business, but professional business service companies will not locate in an area unless there is enough start-up activity to sustain their business costs. Utah has many innovative start-up companies that often do not become successful anchor companies, generally due to acquisition or desire to maintain status quo. Utah does have a presence of law firms, accounting firms, and underwriting firms that assist in the flow of capital and equity, but does not have a fully developed network of professional business services. In Silicon Valley, law firms, accounting firms, underwriting firms, investment bankers, consulting firms, and headhunter firms form a network that creates a warm nesting bed, perfect for hatching successful start-ups. Utah will probably have difficulty developing a mature network of professional services until the amount of capital and the quality of start-ups justify its formation.

Following is a list of the most frequently used professional business services companies located in Utah⁵³.

Law Firms – Law Firms Involved in IPOs, Secondary Offerings, Debt Offerings or Venture Capital Deals

1. Dorsey & Whitney LLP
2. Durham Jones & Pinegar
3. Parr Waddoups Brown Gee & Loveless
4. Parsons Behle & Latimer
5. Stoel Rives LLP
6. Wilson Sonsini Goodrich & Rosati

Accounting Firms – Major Accounting Firms Involved in IPOs, Secondary Offerings, Debt Offerings or Venture Capital Deals

1. Arthur Andersen LLP
2. Ernst & Young
3. Hansen Barnett & Maxwell
4. KPMG
5. PricewaterhouseCoopers LLP

Underwriters

1. Goldman, Sachs & Co.
2. Raymond James Financial Services

STATE GOVERNMENT

The example of the Colorado case study shows that government can influence the development of a technology growth center. Governor Roy Romer played a key role developing the policies and programs that have advanced technology growth in Colorado. He declared the State of Colorado as being “Open for Businesses,” instigating several economic development programs, helping to make Colorado’s regulations and taxes more business friendly.

To maximize the success of technology development in Utah, the State needs to articulate existing practices and incorporate new initiatives into a written, long-term development strategy. This strategy should augment the existing strategy and can be communicated to and drawn upon by all parties associated with the economic development of Utah. Initiatives such as the doubling and tripling of the number of engineers in the State and targeting technology companies should be enhanced with other measures to maximize Utah’s goal for technology development.

Today Utah’s on-going programs include: the Urban Development Program which recruits business to the metropolitan areas of the state; the Rural Development Program which coordinates with rural areas of Utah for recruitment of industry; the business Development Program which is charged with helping existing businesses and with developing state financing initiatives; the International Development Program which works to attract foreign investment to Utah, to encourage export of Utah products; and the Centers for Excellence Program which encourages greater ties between Utah’s colleges and universities and the private sector.

While these programs have found some success in achieving their goals, their *success* can be maximized in the light of a system where productivity and innovative capacity are also emphasized as measures of progress beyond the current goals.

CULTURE

Utah’s labor, firm, and industrial cultures should be more conducive to world-class, high-tech business development. As was highlighted in the contrasting study of Route 128 and Silicon Valley, culture plays a major role in dictating the motivation and values of individuals and organizations.

- Labor Culture – Individuals, especially entrepreneurs, should be less risk averse and have a passion for their jobs; open to working long hours 6 or 7 days a week. In Silicon Valley, the line between one’s work life and private life is less distinct than it is in Utah’s culture.
- Firm Culture – Firms should exhibit a horizontal corporate structure that is based upon a meritocracy. Firms in which any employee regardless of degree or age can take

an idea and run with it are critical for an organization to adapt and innovate. Firms should also tolerate movement by employees.

- Industrial Culture – Firms should be open and clustered together. There must be a high degree of sharing formally and informally. In Silicon Valley it is common for the CEO of one company to call upon the CEO of a competitor to talk.

RECOMMENDATIONS

The following recommendations are initiatives that can be undertaken by the State government to influence the development of a habitat or system of world-class innovation and entrepreneurship.

Education

Recommendation #1: Bring world-class knowledge to the state through the attraction of academics for lectures, seminars, professorships, and research positions.

Recommendation #2: Attract an individual with an extensive high-tech network to an important academic administration position. A leading high-tech figure could greatly enhance a university's role in state economic development.

Recommendation #3: Encourage universities to reward technological innovation by including it in the criteria for tenure and promotion. Establish a super-scale of remuneration, or find other means to compensate those new and existing faculty whose superstar status is sought for designated programs.

Recommendation #4: Creation of specialized schools and departments within the universities to develop the real-world application of new technologies. Meet with experts to discuss what new high-tech school could be established at the University of Utah or Utah State University.

Recommendation #5: Advance the development and interest of technology and entrepreneurship at a young age by organizing engineering and entrepreneurial projects between Utah students K-12 and local industry.

Recommendation #6: Create a statewide electronic network that would connect educational institutions at all levels. The network would link classrooms, libraries, laboratories, workshops and conference rooms via voice, data, graphics and images-based interactive communications.

The keys are

*1) To have first - rate universities working on practical problems (not necessarily Noble prize science) and
2) Maintain an environment that makes high - income, high - education individuals want to live there.*

*You have all the assets you need for #2. But more progress on issues like air pollution and innovative approaches to such amenities as open space would help. The big challenge for Utah is #1. Think about the big new schools in the past - Chemical Engineering, which was first introduced at MIT in the 1920s. Or computer science - which did not exist before 1950. **What new type of school could Utah pioneer?***

Consider, for example, computer engineering -- the applied side of software -- instead of computer science? There is no good academic training in the US in how to actually write computer code or manage complicated software projects.

Dr. Paul Romer
Professor of Economics
Stanford University

Named one of America's 25 most influential people by
Time magazine in 1997

Recommendation #7: Create an Industrial Education Committee comprised of educators and business leaders to discuss how to further develop a strategic workforce education program tailored to technology industry needs.

Recommendation #8: Establish programs at the State universities that further facilitate collaboration with industry in research and development initiatives. Play an influential role in recruiting leading companies to establish partnerships with researchers at the State's institutions.

Recommendation #9: Play an active role in the development of entrepreneur programs at State universities. Bachelors and master's programs in computer science, engineering, and the life sciences should emphasize entrepreneurial training and incentives.

Utah is an exporter of both technology and technical talent. There is not a sufficient industrial base to employ the engineers we produce.
A Local Professor

Recommendation #10: Develop local social networks that leverage Utah's high-tech growth and support its high-tech companies. Instigate forums for discussion among academics and industry experts.

Businesses

Recommendation #11: Encourage further university-industry collaboration by offering a generous R&D tax credit to companies that engage in research and development activities with the State's universities.

The state should encourage more interaction between local industry and the engineering faculty at universities within the state. Perhaps industry could be given tax credits when they sponsor research at universities within the state.
A Local Professor

Recommendation #12: Plan for and develop additional industrial parks where clusters of companies can locate. Utah should continue developing a critical mass of companies in close proximity as part of the innovation system. This allows companies to drive each other to innovate while employees develop informal networks of learning.

Recommendation #13: When recruiting companies, Utah should continue to focus on promising, innovative start-ups and intellectual capital-producing divisions of anchor companies. This involves attracting companies that build upon Utah's existing competencies in biotechnology, software, and specialized computer hardware components.

Recommendation #14: Offer a simple, coordinated, and expeditious process for obtaining multiple new business permits and approvals.

Recommendation #15: Work with research programs in competing for federal grants by more aggressively pursuing federal funding for university research.

Recommendation #16: Proliferate non-profit incubator organizations that provide capital, technology transfer assistance, and contacts for new start-ups. Ideally these organizations would coordinate support services to entrepreneurs through the commercialization process. Specifically, these centers could provide low-cost facilities; and connect entrepreneurs to capital, business skills training, and university training programs

Recommendation #17: Create the Utah Science and Technology Council to identify barriers to growth in the science and technology industries and recommend measures to reduce such barriers. The council should be composed of the state's leading CEOs, universities and government officials.

Recommendation #18: Host or sponsor high-tech industry trade shows to the State that will promote the flow of ideas between companies and draw attention to the State.

Capital

Recommendation #19: Strengthen the role of state government in raising, attracting, and retaining venture capital. The following are suggested strategies that the state could employ to facilitate this process:

Aggressive strategy. Invest state-controlled funds in venture capital pools. Most venture capital comes from insurance companies, pension funds, university endowments, at least in established areas. Regions at an earlier stage in the process should ramp up public-sector VC funds (by diversifying their pension fund portfolios, for example).

Neutral strategy. Encourage angel investing through state-run matchmaking programs. States can catalyze venture funding by holding “venture network” forums that bring the state's most likely investors (prominent, wealthy individuals) and its best entrepreneurs together for periodic (bimonthly) conferences. The state could also guarantee a 6 percent return for in-state investment by Industrial Loan Corporations. This could prompt these corporations to invest, in Utah, the hundreds of millions of dollars they are required to invest locally by law.⁵⁴

Physical Infrastructure

Recommendation #20: Continue to guide development to appropriate locations where infrastructure is already in place, where the environmental conditions are sufficiently stable to sustain further growth, where efficient public transit service is available, and where appropriate urban housing and services exist for a higher standard of living.

Recommendation #21: Increase the frequency of non-stop international flights from Salt Lake International Airport to airports around the world. International access can enhance the State's ability to do business globally and to attract foreign investment and collaboration.

Recommendation #22: Work towards establishing a metroplex by linking the Salt Lake and Provo/Orem economies. One way to instigate this process is through the issuance of State bonds to develop TRAX from Ogden to Spanish Fork within three years, as infrastructure investment is directly related to the ability of the economy to grow and increase its productivity.

State

Recommendation #23: Utah should focus on raising the standard of living for all citizens by increasing per-capita income through high-productivity industries. In this next stage of growth, job creation initiatives should be focused on per-capita income.

Expand the Centers of Excellence Program. Encourage faculty to start companies. They could/should provide more small business development grants.

A Local Professor

Recommendation #24: Encourage greater state, regional, and local cooperation for economic development. More coordination between Utah's economic development programs can reinforce the State's high-tech network.

Recommendation #25: Further develop Utah's ethnic centers in sections of downtown Salt Lake such as "Little Mexico," "Greek Town," "China Town," and others, to highlight Utah's diverse cultures.

APPENDIX A: A Comparison of High-technology Centers

Source: Joseph Cortright & Heike Mayer. "A Comparison of High-technology Centers"
Portland State University: April 2000 Regional Connections working paper #4

Table 2: Population and Income Characteristics of Selected Metropolitan Areas, 1997.

Metropolitan Area	Population 1997	Growth 1990-97	Per Capita Income	Growth 1990-97	Percent of US Average
Boston	5,826,816	0.3%	31,808	4.3%	119%
Atlanta	3,634,245	2.8%	28,253	4.4%	105%
Phoenix	2,842,030	3.4%	24,137	4.0%	90%
Minneapolis	2,794,939	1.3%	30,123	4.4%	112%
San Diego	2,723,711	1.1%	24,965	3.0%	93%
Seattle	2,279,236	1.5%	33,373	5.0%	124%
Denver	1,901,927	2.2%	30,743	5.0%	115%
Portland	1,789,790	2.3%	27,388	4.8%	102%
San Jose	1,620,453	1.1%	37,856	5.6%	141%
Sacramento	1,503,900	1.5%	25,335	3.4%	94%
Salt Lake City	1,250,854	2.1%	22,264	5.3%	83%
Austin	1,069,755	3.3%	25,420	5.3%	95%
Raleigh-Durham	1,050,358	2.8%	27,711	4.8%	103%
These 13 Metros	30,288,014	1.7%	28,921	4.4%	108%
All US Metropolitan Areas	214,137,630	1.1%	26,840	4.0%	100%

Source: Bureau of Economic Analysis, Regional Economic Information System.

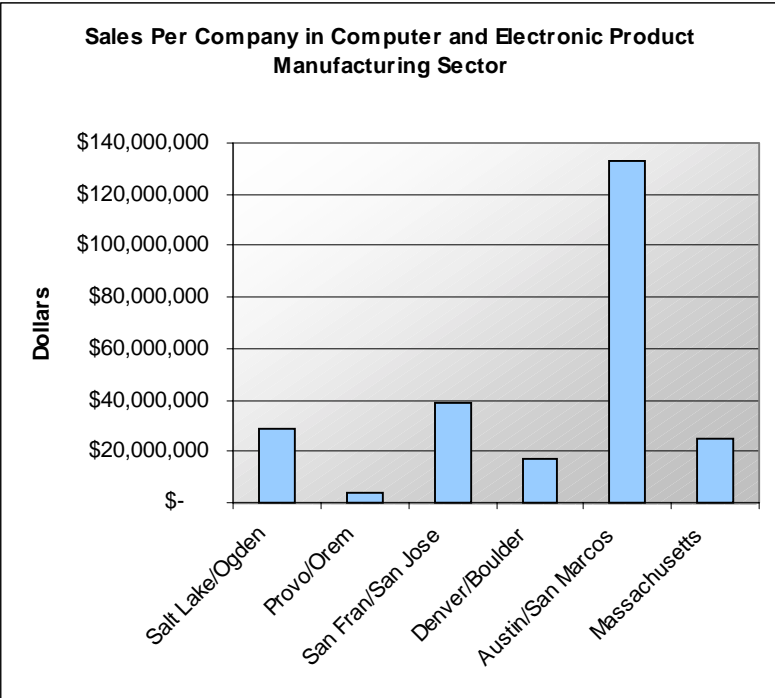
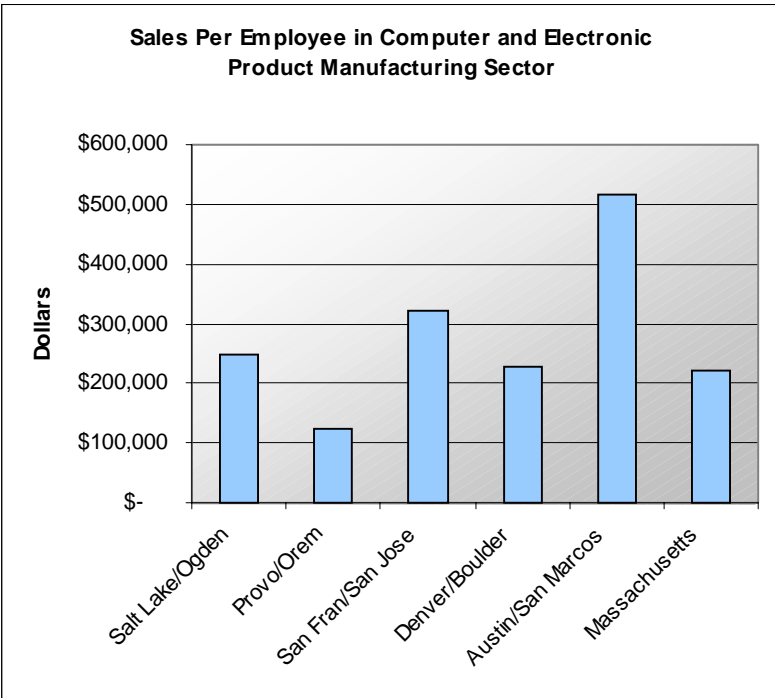
Note: Dollars are current dollars, US per capita average income is the average for all metropolitan areas.

Table 4: Estimated High Technology Employment in Selected Metropolitan Areas, 1996. (County Business Patterns)

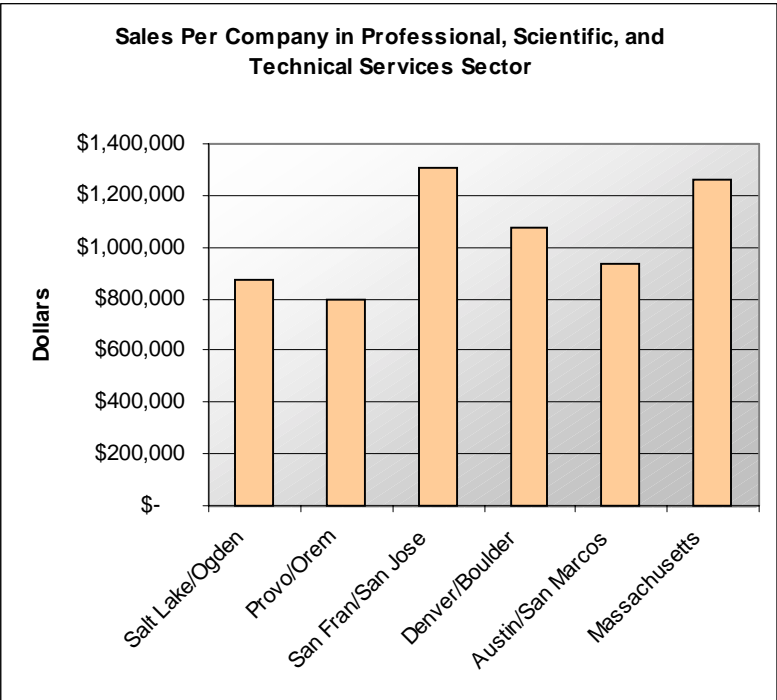
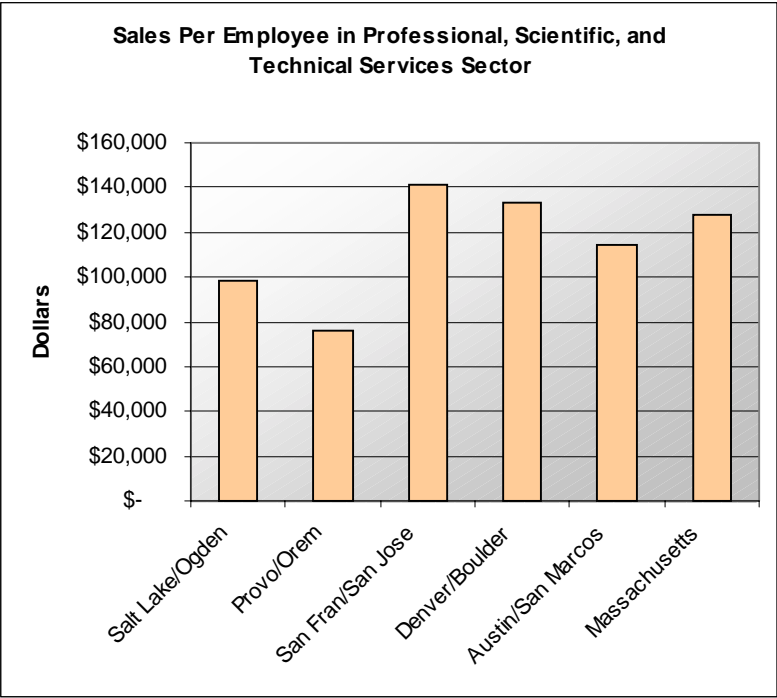
REGION	Employment	Payroll	Establishments	Average Pay
San Jose	189,601	13,322,050	3,330	\$ 70,264
Boston	170,348	8,579,542	4,105	\$ 50,365
Minneapolis	82,064	2,858,571	2,638	\$ 34,833
Atlanta	67,114	2,944,946	3,087	\$ 43,880
San Diego	56,315	2,590,749	1,632	\$ 46,005
Phoenix	54,694	2,647,429	1,443	\$ 48,404
Seattle	54,556	3,090,220	1,990	\$ 56,643
Austin	48,142	2,309,524	912	\$ 47,973
Raleigh-Durham	47,672	1,141,008	866	\$ 23,935
Portland	43,230	1,539,344	1,233	\$ 35,608
Denver	31,927	1,435,743	1,748	\$ 44,970
Salt Lake City	25,403	746,170	672	\$ 29,373
Sacramento	14,550	607,078	444	\$ 41,724

Source: Authors Calculations from County Business Pattern Data

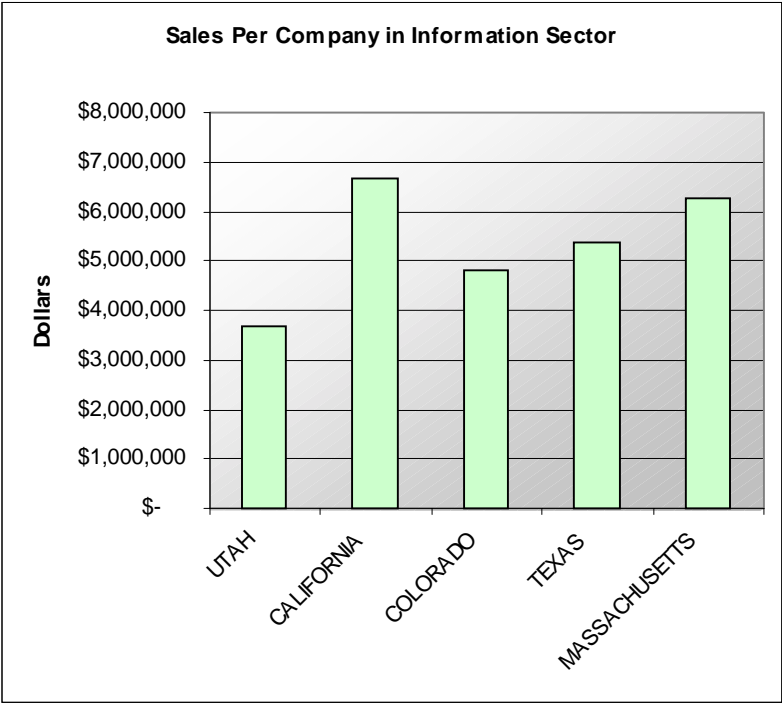
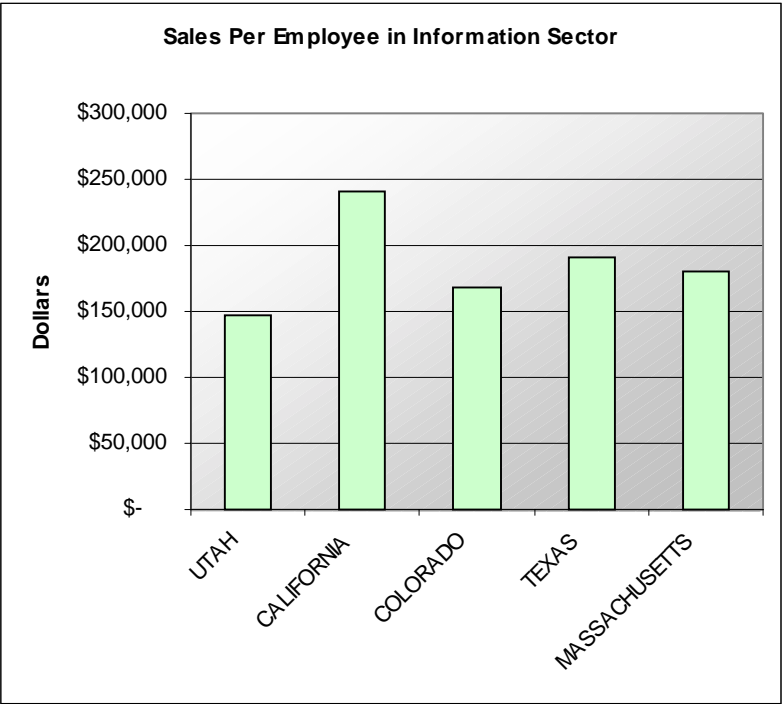
APPENDIX B: Sales Per Employee in Computer and Electronic Product Manufacturing Sector



APPENDIX C: Sales Per Employee in Professional, Scientific, and Technical Services Sector



APPENDIX D: Sales Per Employee in Information Sector



APPENDIX E: NAICS Industry Code Descriptions

NAICS 334: Computer and Electronic Product Manufacturing

Industries in the Computer and Electronic Product Manufacturing sub sector group establishments that manufacture computers, computer peripherals, communications equipment, and similar electronic products, and establishments that manufacture components for such products. The design and use of integrated circuits and the application of highly specialized miniaturization technologies are common elements in the production technologies of the computer and electronic sub sector. Convergence of technology motivates this NAICS sub sector. Digitalization of sound recording, for example, causes both the medium (the compact disc) and the equipment to resemble the technologies for recording, storing, transmitting, and manipulating data. Communications technology and equipment have been converging with computer technology.

NAICS Sector: 54 Professional, Scientific, and Technical Services

The Professional, Scientific, and Technical Services sector comprises establishments that specialize in performing professional, scientific, and technical activities for others. These activities require a high degree of expertise and training. The establishments in this sector specialize according to expertise and provide these services to clients in a variety of industries and, in some cases, to households. Activities performed include: legal advice and representation; accounting, bookkeeping, and payroll services; architectural, engineering, and specialized design services; computer services; consulting services; research services; advertising services; photographic services; translation and interpretation services; veterinary services; and other professional, scientific, and technical services.

NAICS Sector: 51 Information

The Information sector comprises establishments engaged in the following processes: (a) producing and distributing information and cultural products, (b) providing the means to transmit or distribute these products as well as data or communications, and (c) processing data.

The main components of this sector are the publishing industries, including software publishing, the motion picture and sound recording industries, the broadcasting and telecommunications industries, and the information services and data processing industries.

APPENDIX F: Productivity Data by Metro Area and State

PRODUCTIVITY DATA BY METRO AREA AND STATE

Source: US Census Bureau - 1997 Economic Census

	NAICS CODE	Description	Establishments	Value of Sales/Shipment (\$1,000)	Annual Payroll (\$1,000)	Paid Employees	Employees/ company	Avg. Salary	Sales/employee
Salt Lake/Ogden									
		Computer & electronic product							
	334 mfg		116	\$ 3,373,560,000	\$ 533,667,000	13,691	118.0	\$ 38,979	\$ 246,407
	54 services (taxable)		2,966	\$ 2,590,209,000	\$ 1,005,296,000	26,458	8.9	\$ 37,996	\$ 97,899
Provo/Orem									
		Computer & electronic product							
	334 mfg		28	\$ 114,686,000	\$ 28,837,000	933	33.3	\$ 30,908	\$ 122,922
	54 services (taxable)	Professional, scientific, & technical	582	\$ 463,272,000	\$ 195,252,000	6,094	10.5	\$ 32,040	\$ 76,021
UTAH									
	51 Information		971	\$ 3,567,739,000	\$ 807,910,000	24,253	25.0	\$ 33,312	\$ 147,105
San Francisco/									
Oakland/									
		Computer & electronic product							
	334 mfg		1,729	\$ 67,452,958,000	\$ 11,647,767,000	210,661	121.8	\$ 55,292	\$ 320,197
San Jose									
		Professional, scientific, & technical	24,040	\$ 31,367,960,000	\$ 12,686,895,000	221,672	9.2	\$ 57,233	\$ 141,506
CALIFORNIA									
	51 Information		16,302	\$ 108,719,084,000	\$ 22,868,487,000	450,511	27.6	\$ 50,761	\$ 241,324
Denver/Boulder/									
Greeley									
		Computer & electronic product							
	334 mfg		282	\$ 4,910,782,000	\$ 1,027,850,000	21,607	76.6	\$ 47,570	\$ 227,277
	54 services (taxable)	Professional, scientific, & technical	9,909	\$ 10,676,214,000	\$ 3,768,867,000	79,903	8.1	\$ 47,168	\$ 133,615
COLORADO									
	51 Information		2,653	\$ 12,743,005,000	\$ 3,306,300,000	76,024	28.7	\$ 43,490	\$ 167,618
Austin/									
San Marcos									
		Computer & electronic product							
	334 mfg		149	\$ 19,848,363,000	\$ 1,665,741,000	38,357	257.4	\$ 43,427	\$ 517,464
	54 services (taxable)	Professional, scientific, & technical	3,699	\$ 3,460,547,000	\$ 1,392,237,000	30,168	8.2	\$ 46,149	\$ 114,709
TEXAS									
	51 Information		7,520	\$ 40,363,181,000	\$ 8,605,583,000	210,654	28.0	\$ 40,852	\$ 191,609
MASSACHUSETTS									
		Computer & electronic product							
	334 mfg		926	\$ 23,336,824,000	\$ 5,073,299,000	105,506	113.9	\$ 48,085	\$ 221,190
	54 services (taxable)	Professional, scientific, & technical	18,086	\$ 22,744,095,000	\$ 9,261,354,000	177,345	9.8	\$ 52,222	\$ 128,248
MASSACHUSETTS									
	51 Information		3,282	\$ 20,548,868,000	\$ 5,395,718,000	113,698	34.6	\$ 47,457	\$ 180,732

APPENDIX G: Largest Highest Tech Firms

Source: Joseph Cortright & Heike Mayer. "A Comparison of High-technology Centers"
Portland State University: April 2000 Regional Connections working paper #4

Table 11: Largest High Tech Firms and Those Most Frequently Appearing Among the Ten Largest High Tech Employers, Selected Metropolitan Areas, 1997.

Metro Area	Largest Firm	Hewlett-Packard	IBM	Intel	Motorola	Lucent
Atlanta	Lucent	4	2			1
Austin	Dell		3		2	3
Boston	Raytheon	6	4*			
Denver			Not available			
Minneapolis	Honeywell					
Phoenix	Motorola			2	1	6
Portland	Intel	4	3*	1		
RTP	IBM		1		7	
Sacramento	Hewlett Packard	1		2		
Salt Lake	Novell					
San Diego	Qualcomm	4				
San Jose	Hewlett Packard	1		2		
Seattle	Microsoft	6				

Note: Numbers in each column correspond to each company's rank among the ten largest high tech employers in each metropolitan area. For example, Hewlett Packard is the fourth largest high tech employer in Atlanta, 6th largest in Boston, and so on. * - Lotus Development Corporation (Boston) and Sequent Computer (Portland), both acquired by IBM, are counted as IBM subsidiaries in this table.
Source: Authors' calculations, see text.

APPENDIX H: Austin Anchor Firms

Austin Anchor Firms, 1980

Sales Company name	Industry name
295.147 TRACOR INC	SRCH,DET,NAV,GUID,AERO SYS

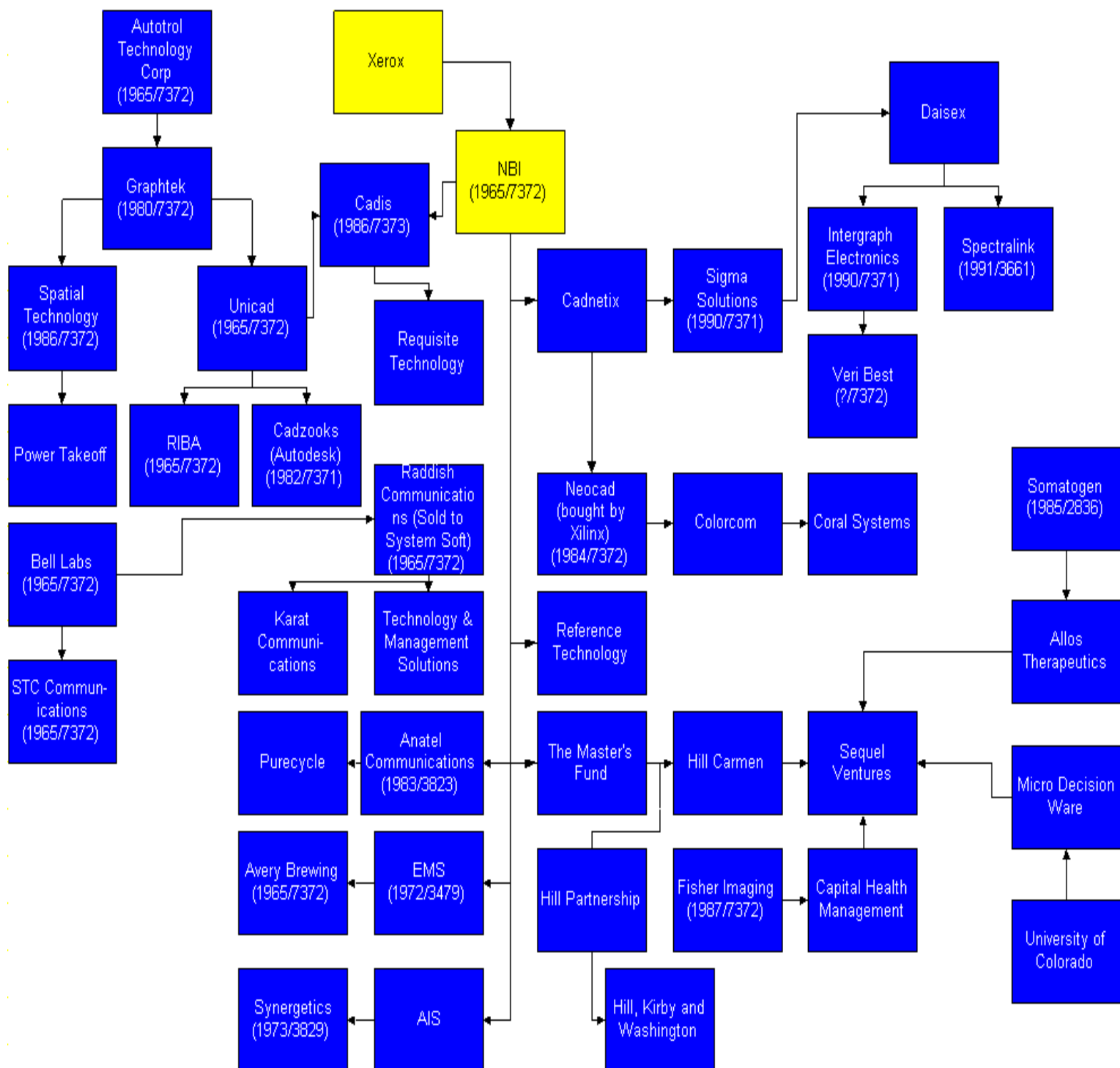
Austin Anchor Firms, 1999

Sales Company name	Industry name
25265 DELL COMPUTER CORP	ELECTRONIC COMPUTERS
431.827 THERMOQUEST CORP	LAB ANALYTICAL INSTRUMENTS
329.583 NATIONAL INSTRUMENTS CORP	PREPACKAGED SOFTWARE

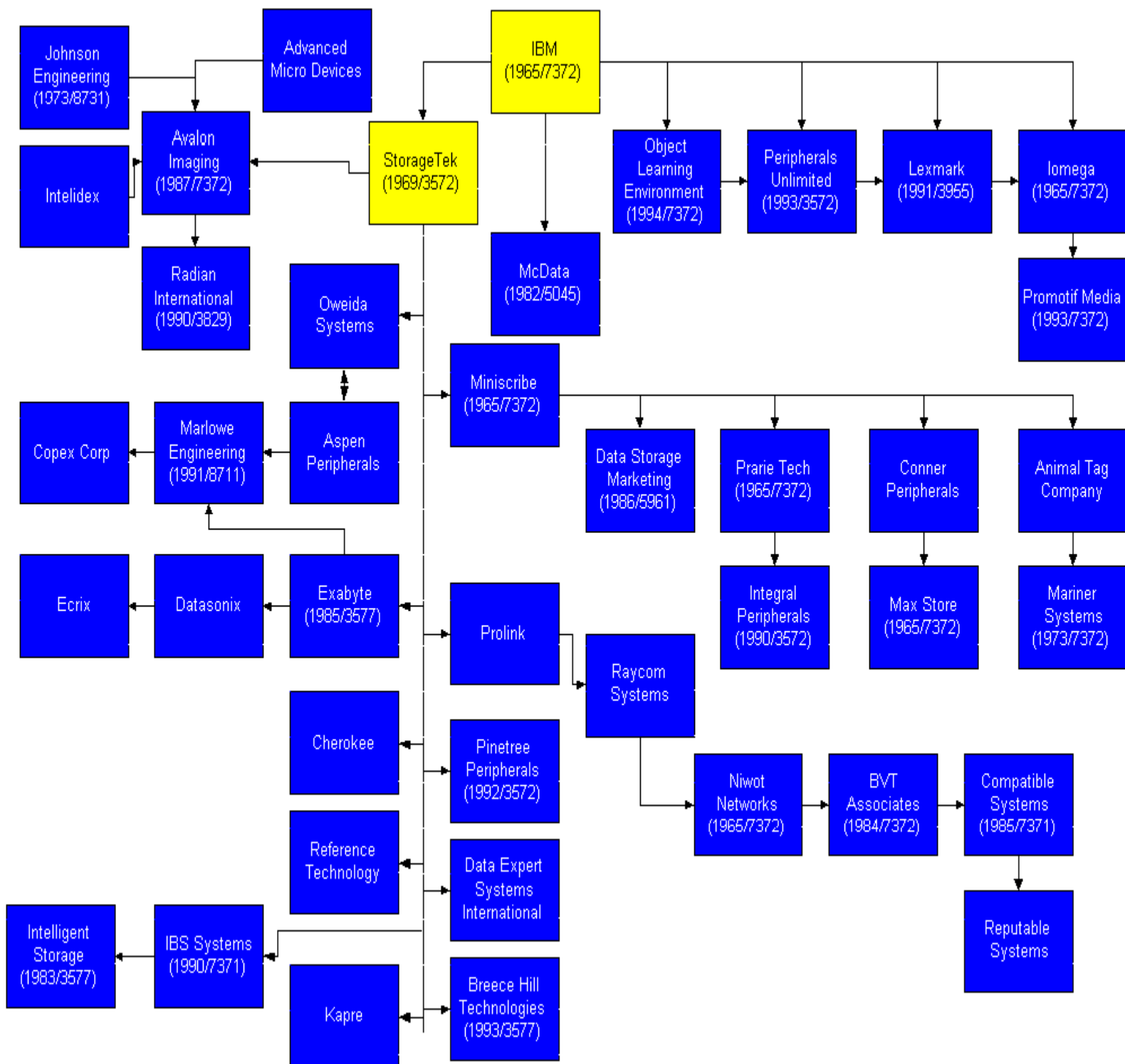
APPENDIX I: Boulder Family Tree, History of Company Spin-offs

Source: The Boulder County Genealogy Study "Family Tree"

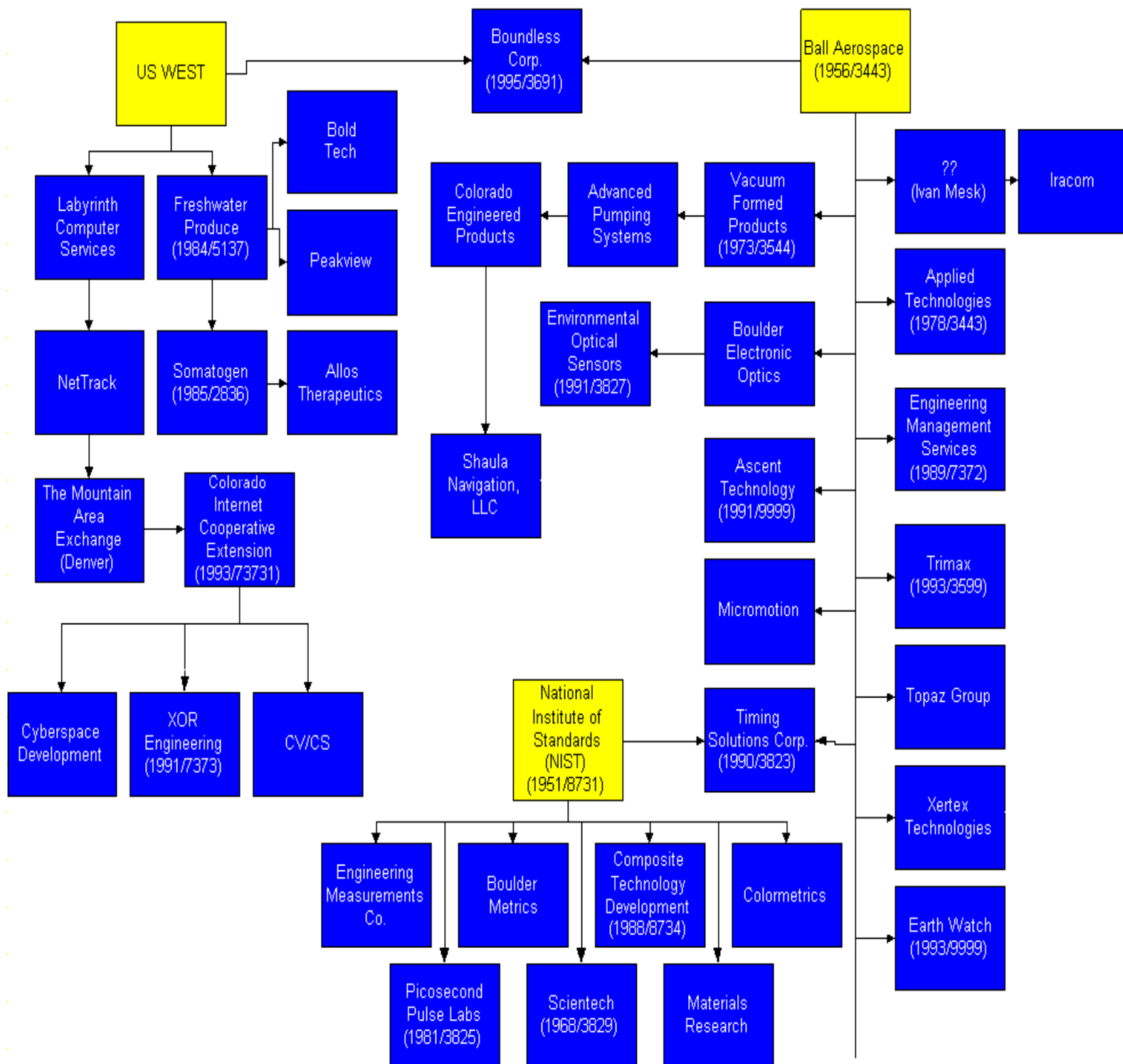
<http://bus.colorado.edu/faculty/meyer/tree.htm>



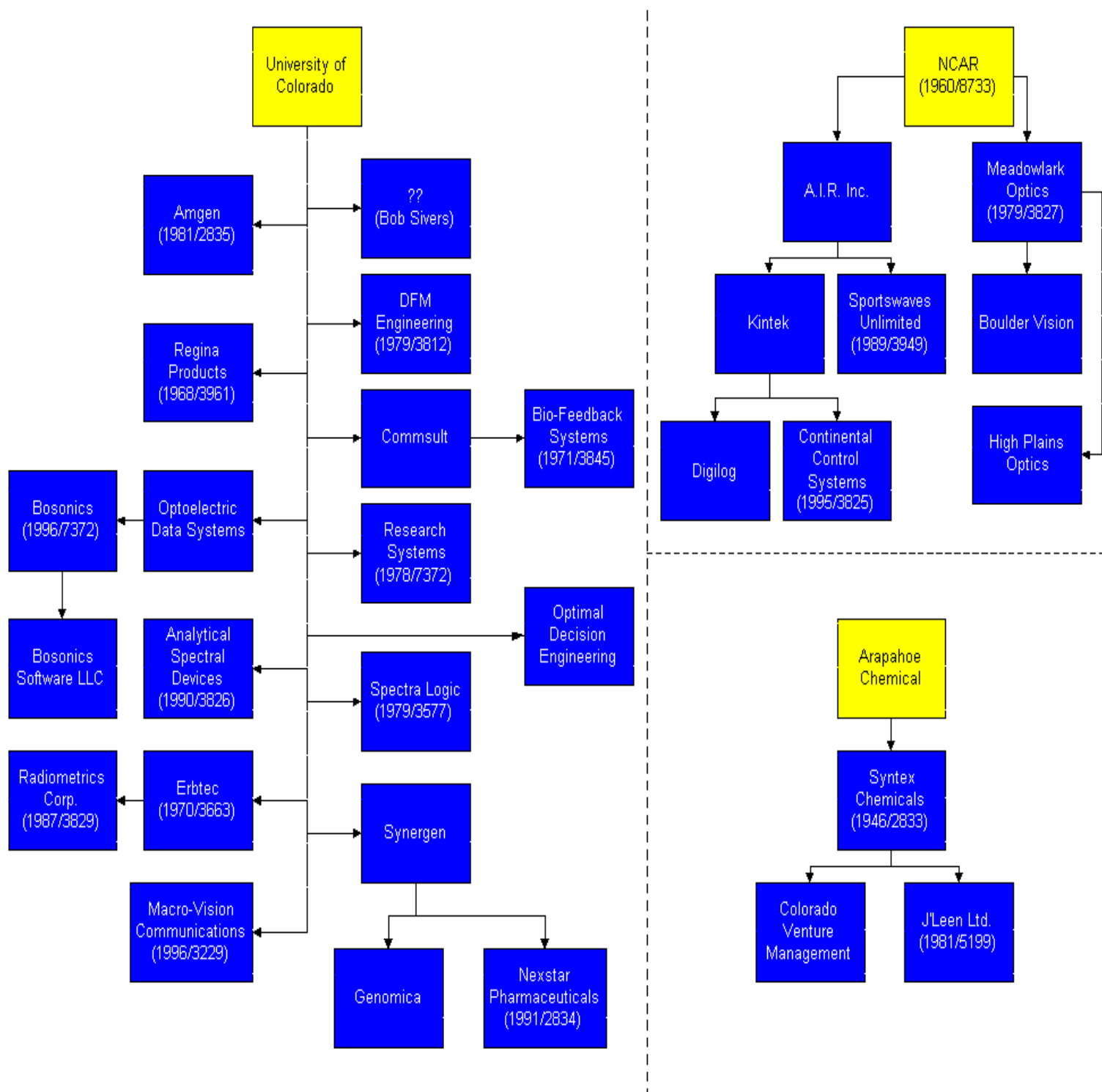
Appendix I: Boulder Family Tree, History of Company Spin-offs (continued)



Appendix I: Boulder Family Tree, History of Company Spin-offs (continued)



Appendix I: Boulder Family Tree, History of Company Spin-offs (continued)



APPENDIX J: Route 128 Anchor Firms

Route 128 Anchor Firms, 1980

Sales*	Company name	Industry name
5002.082	RAYTHEON CO -CL B	SRCH,DET,NAV,GUID,AERO SYS
1450.785	POLAROID CORP	PHOTOGRAPHIC EQUIP & SUPPL
613.093	PERKINELMER INC	LAB ANALYTICAL INSTRUMENTS
543.272	WANG LABS INC	PREPACKAGED SOFTWARE
509.057	FOXBORO CO	INDUSTRIAL MEASUREMENT INSTR
385.586	OAK INDUSTRIES INC	ELECTRONIC CONNECTORS
322.48	M/A-COM INC	ELECTRONIC COMPONENTS, NEC

Route 128 Anchor Firms, 1999

Sales *	Company name	Industry name
20041	RAYTHEON CO -CL B	SRCH,DET,NAV,GUID,AERO SYS
6715.61	EMC CORP/MA	COMPUTER STORAGE DEVICES
2842	BOSTON SCIENTIFIC CORP	SURGICAL,MED INSTR,APPARATUS
2471.193	THERMO ELECTRON CORP	LAB ANALYTICAL INSTRUMENTS
1978.6	POLAROID CORP	PHOTOGRAPHIC EQUIP & SUPPL
1790.912	TERADYNE INC	ELEC MEAS & TEST INSTRUMENTS
1450.379	ANALOG DEVICES	SEMICONDUCTOR,RELATED DEVICE
1363.129	PERKINELMER INC	LAB ANALYTICAL INSTRUMENTS
1057.601	PARAMETRIC TECHNOLOGY CORP	PREPACKAGED SOFTWARE
1041.092	KEANE INC	COMPUTER PROGRAMMING SERVICE
920.722	MANUFACTURERS SVCS LTD	ELECTRONIC COMPONENTS, NEC

* Sales in Millions

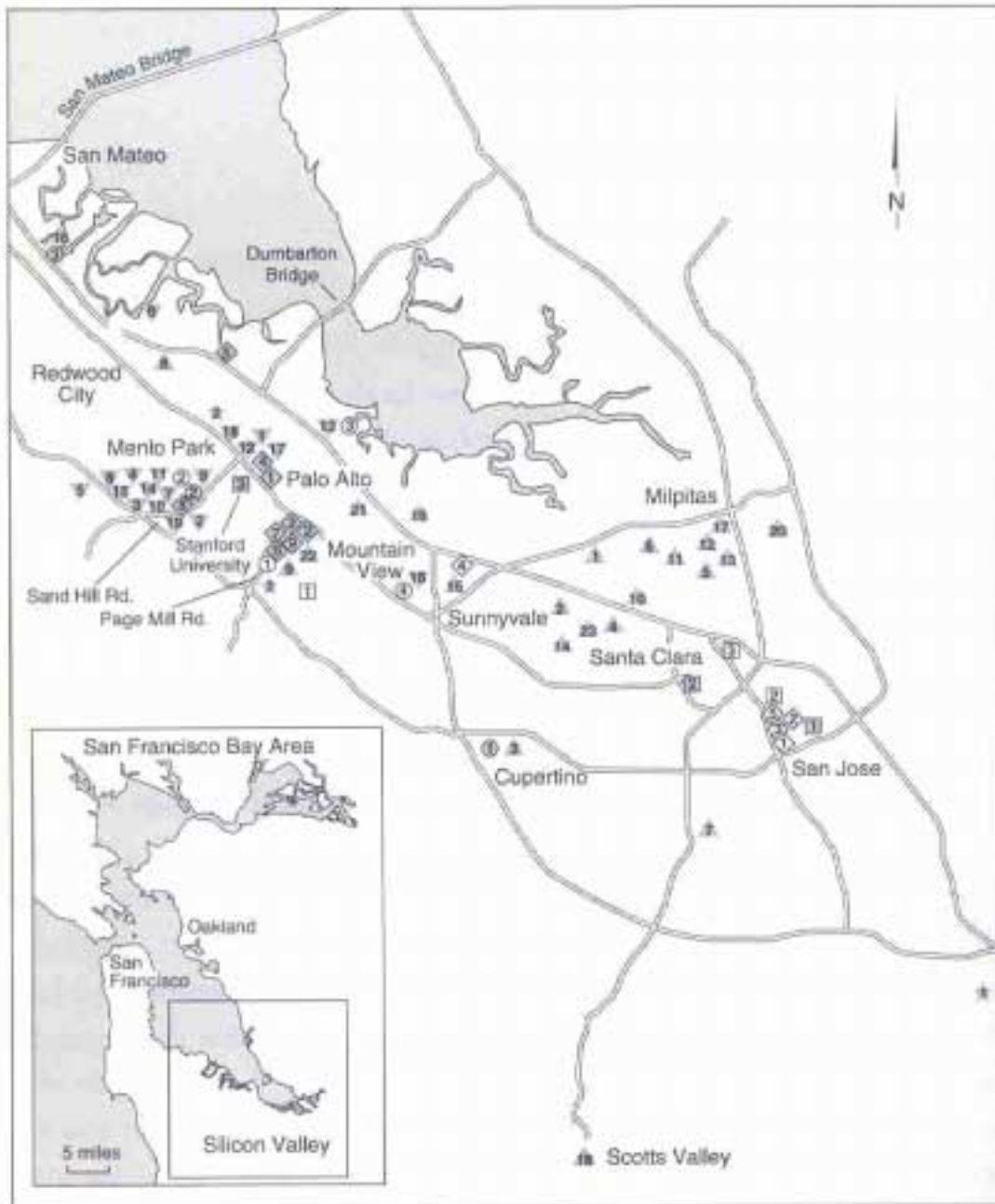
APPENDIX K: Fairchild's Offspring

Source: *Business Week* – August 25, 1997 pg. 84



APPENDIX L: Silicon Valley Microclusters

Source: Lee, Chong Moon; Miller, William F.; Hancock, Marguerite Gong; Rowen, Henry S. 2000. *The Silicon Valley Edge: A Habitat for Innovation and Entrepreneurship*



- ▲ Technology Companies
- Consultants
- Universities
- ◆ Law Firms, Accounting Firms
- ▼ Venture Capital Firms
- ☆ Research

Source: *Business Week* – August 25, 1997 pg. 82-3

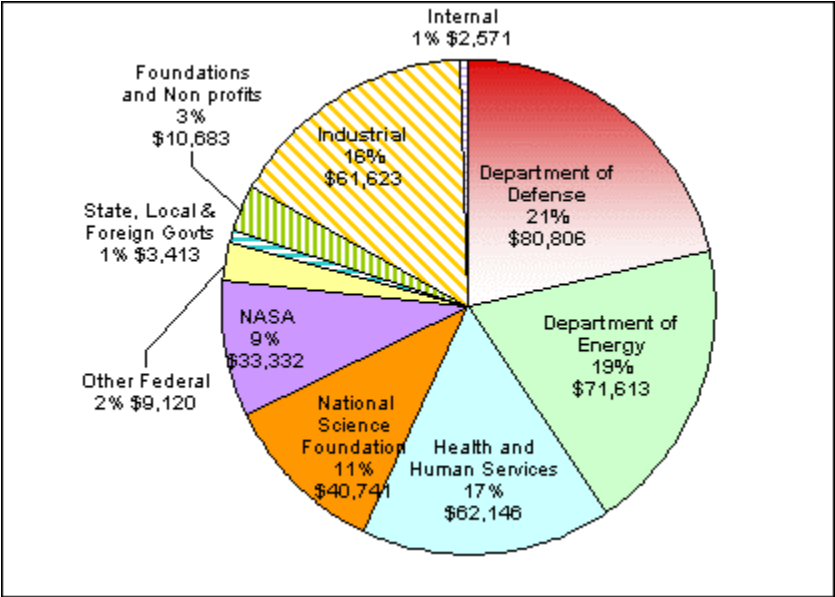


APPENDIX N: Silicon Valley Anchor Firms

Sales	Company name	Industry name
29389	INTEL CORP	SEMICONDUCTOR,RELATED DEVICE
11726.3	SUN MICROSYSTEMS INC	ELECTRONIC COMPUTERS
10130.13	ORACLE CORP	PREPACKAGED SOFTWARE
8391.4	SOLETRON CORP	PRINTED CIRCUIT BOARDS
8331	AGILENT TECHNOLOGIES INC	ELEC MEAS & TEST INSTRUMENTS
6802	SEAGATE TECHNOLOGY	COMPUTER STORAGE DEVICES
6134	APPLE COMPUTER INC	ELECTRONIC COMPUTERS
4727.204	QUANTUM CORP-CONSOLIDATED	COMPUTER STORAGE DEVICES
3311.579	QUANTUM CORP HDDG	COMPUTER STORAGE DEVICES
2857.604	ADVANCED MICRO DEVICES	SEMICONDUCTOR,RELATED DEVICE
2748.957	SILICON GRAPHICS INC	ELECTRONIC COMPUTERS
2486.123	MAXTOR CORP	COMPUTER STORAGE DEVICES
2139.9	NATIONAL SEMICONDUCTOR CORP	SEMICONDUCTOR,RELATED DEVICE
2089.444	LSI LOGIC CORP	SEMICONDUCTOR,RELATED DEVICE
1429.146	PEOPLESOFT INC	PREPACKAGED SOFTWARE
1420.011	ELECTRONIC ARTS INC	PREPACKAGED SOFTWARE
1418.871	QUANTUM CORP DSSG	COMPUTER STORAGE DEVICES
1330.161	ATMEL CORP	SEMICONDUCTOR,RELATED DEVICE
1214.744	SANMINA CORP	PRINTED CIRCUIT BOARDS
1093.303	CADENCE DESIGN SYS INC	PREPACKAGED SOFTWARE

Sales in millions of dollars

APPENDIX O: MIT's Research Sponsorship for 1999
Source: MIT.edu



APPENDIX P: Technology Transfer at the University of Utah

UNIVERSITY OF UTAH

Despite filing for fewer patents annually, the University of Utah has done fairly well in the area of technology transfer, ranking first and second among America's universities in the number of inventions per million dollars of research and in the number of license agreements with industry. Further, it currently spends over double the national average on research expenditures from industry, typically 11 to 15 percent. Another important implication of the University of Utah's research base is the skilled workforce created through such programs, providing students with real world, interactive educational experiences.⁵⁵

The University of Utah, referred to as the birthplace of computer graphics, has employed and educated a number of former faculty members and alumni that have made significant contributions to the technology industry. Adobe Systems and WordPerfect were co-founded respectively by John Warnock and Alan Ashton. Alan Kay, father of the personal computer, also developed the Macintosh user interface including overlapping windows, pull down menus, and the use of icons--now also found in scores of computer programs. Silicon Graphics and Netscape were founded by Jim Clark, and Evans & Sutherland co-founded by David Evans. Tom Stockham developed the digital technology that made possible the CD and CD-ROM.⁵⁶

University of Utah's research park and a number of research programs have played an significant role and will continue to play an even more important role in Utah's high-tech activity. Below is a listing of research entities at the University of Utah, as well as a synopsis of several notable programs that have had a major influence on the university's research endeavors.

CENTERS AND INSTITUTES, RESEARCH

Computer/Information Technology

- Asynchronous Circuit and System Design, Center for
- Computer Graphics and Scientific Visualization, Center for
- Engineering Experiment Station - Utah
- High Performance Computing, Center for
- Micro Instrumentation Laboratory
- Scientific Computing and Imaging, Center for

Biotechnology

- Applied Dosimetry, Center for
- Biopolymers at Interfaces, Institute for
- Cardiovascular Research and Training, Institute for

- Cell Signaling, Center for
- Clinical Research, Center for
- Engineering Design, Center for
- Resource for Genetic and Epidemiologic Research (RGE), Center for
- Howard Hughes Medical Institute
- Human Genome Research, Center for
- Human Toxicology, Center for
- Huntsman Cancer Institute (HCI)
- Perinatal Genetics Research Lab
- Radiological Health, Center for
- Remote Sensing and Cartography, Center for

Other Scientific Research Entities

- Combustion Research Group
- Energy and Geoscience, Institute for
- High Energy Astrophysics Institute for
- Laser Institute
- Micro-Analysis and Reaction Chemistry, Center for
- Nuclear Technology, Engineering and Research, Center for

University of Utah Tech Transfer Office (TTO)

University of Utah's Technology Transfer Office (TTO) typically receives royalties of several million dollars a year on the sales of licensed products and, on average, spins off six new start-up companies as a result of its research endeavors. Further, companies that license resulting inventions invest over \$25 million a year in the development of new products.

Technology Access Report ranked University of Utah's TTO second nationally, based on a six-factor technology transfer study. The study based its rankings on the average number of new companies formed, number of licenses executed, new patents applied for, research funding related to a license, the percentage of research sponsored by industry, and gross license income.⁵⁷

Companies Based on University of Utah Technology and Utah Licensees

Acacia Biosciences, Inc.	Luminal Technologies, L.P.
ACiont, Inc.	Macromed
Advanced Processing Technologies, Inc.	MantiCore Pharmaceuticals, Inc.
Anesta Corporation	MedQuest Pharmacy

Associated Regional and University Pathologists Labs (ARUP)	Micromath, Inc.
Attensity Corporation	Myriad Genetics, Inc.
Axon Medical, Inc.	NPS Pharmaceuticals
James W. Bunger and Associates, Inc.	Parscitech
Bunnell, Inc.	Partnet, Inc.*
Cimarron Software, Inc.*	parvus Corporation*
Cognetix Incorporated	Pharmadigm Inc.
Darbik Instructional Software	Process Instruments, Inc.*
DataChem Laboratories, Inc.	Protein Solutions, Inc.
Echelon Research Labs	Radiant Laboratories
Eleven 5, Inc.	Rocky Mountain Research, Inc.
EM Imaging	Sand Therapeutic, Inc.
Eneco, Inc.	Sarcos Incorporated*
Engineering Geometry Systems, Inc.*	Technical Research Associates, Inc. (TRA)
Ergoweb, Inc.	TechniScan, Inc.
Evans and Sutherland*	Terra Tek, Inc.
Femtoscanner Corporation	Theratech, Inc.
Fffractionation, Inc.	Thermacom
Heartport, Inc.	Topical Testing, Inc.
Idaho Technology Incorporated	Vaxsys Corporation
Innovative Caregiving Resources, Inc.	Viewpoint Manufacturing, Inc.
Iomed, Inc.	Zinetics Medical, Inc.

Centers of Excellence

Established in 1986, Utah's Centers of Excellence program represents a partnership between local universities, government and business, aimed at converting university research and technology into marketable products, new high-tech businesses, and skilled jobs. The University of Utah currently houses 11 Centers of Excellence on its campus, with the goal commercializing its valuable research activities where applicable.

The centers funded at the University of Utah for the fiscal year 1996-97 resulted in six spin-off companies and assistance for 132 more, as well as five patents issued, seven more pending, \$5.33 million in matching funds, and 154 jobs created.⁵⁸



University of Utah Research Park

By 1969 the Utah State Legislature had authorized the development of a research park modeled after the Stanford Research Park. The Research Park constitutes the origins of Utah's high-tech industry and significantly facilitates technology transfer from the University to the private sector.

The Research Park has steadily grown since 1972, when construction began. Today, the park hosts some of Utah's most prominent homegrown technology firms: Evans & Sutherland, Myriad Genetics, NPS Pharmaceuticals, TheraTech, and ARUP. In addition, the renowned Huntsman Cancer Institute is also located on University of Utah's campus, along with Intermountain Health Care facilities.⁵⁹ These facilities have brought out of state investment to the university. Annual in-state productivity of park residents now exceeds \$500 million, representing a payroll of approximately \$225 million for the site's 5,500 employees, over half of which are employed by firms that stem from university origins.⁶⁰

In selecting occupants, the University considers whether beneficial relationships are likely to develop between the University and the company. A 1998 survey of Research Park companies showed that 81 percent of companies use faculty as consultants. Over 60 percent contribute financially to the University. Nearly 60 percent report participation in joint research proposals, and 85 percent use faculty or students in research activities. Many companies also allow University departments to use specialized research equipment, and several encourage continuing education by offering to pay tuition and related costs for employees. All respondents report the Research Park location and access to faculty as assets to their business.⁶¹

APPENDIX Q: Technology Transfer at Utah State University

UTAH STATE UNIVERSITY

Utah State University has built a strong reputation in agriculture, aerospace technology, and engineering related research. The university was recently ranked No. 1 in the nation in the amount of research dollars generated per faculty member. In 1999, Utah State University professors brought in a record \$125 million in research grants. This substantial funding enables students to gain real-world experience, critical to their success in the workplace and, in a larger realm, to Utah's goal of building a highly skilled workforce. Further, research funding also enables Utah State University students to get hands-on experience with state-of-the-art equipment.⁶²

Below is a listing of pertinent research entities and projects at the Utah State University, as well as a synopsis of several notable programs that have had a major influence on the university's research endeavors.

Research Centers & Offices

- Biotechnology Center
- Center for Microbe Detection and Physiology
- Center for Self Organizing Intelligent Systems
- ID2 Research Group: Second Generation
- Instructional Design
- Institute for Antiviral Research
- Mechanical and Aerospace Engineering Department
- Small Grains Breeding/Genetics Program
- Space Dynamics Laboratory

Research Projects

- NASA Get Away Special Program
- Rocky Mountain NASA Space Grant Consortium

Utah Research Institute

The Utah Research Institute (URI) was founded with the objective of fostering collaborative research and other activities among the institutions of higher education in Utah, with the intent of leveraging individual university research strengths and initiatives for statewide benefit. Utah State University furthers this statewide objective through the Utah State University Research Foundation.

The Utah State University Research Foundation is currently working with local government and research entities on a number of research projects to this end, including:

- A collaborative project with TARDEC, the Tank-Automotive Research, Development, and Engineering Committee
- A proposed study to develop computer algorithms improving visualization technology in the vehicular engineering field, in partnership with Visidyne, Inc., a privately held research and development company with recognized leadership in optics and photonics, and funded through SBIR.
- A military/aerospace project jointly developed with Hill Air Force Base.⁶³

Office of Technology Commercialization

Utah State University spends approximately 100 million dollars annually on research. The mission of the Utah State University Office of Technology Commercialization is to benefit the public, the University and its faculty by transferring results of Utah State University research into society via licensing and new business development.⁶⁴

Since the university's inception, the Utah State University Research Park Administration is aware of approximately 75 companies with origins based in Utah State University research or academic programs. These include:

- AgriPhi, Inc.
- Applied Ecological Services
- Bio-West
- CyberSym Technologies
- Envirol, Inc.
- Frontier Scientific
- Integrated Systems Engineering
- Letter Press Software LC
- Sorenson Vision
- Space Dynamics Laboratory
- Specialized Analysis Engineering
- TeraGlobal Communications
- TerraStar, Inc.
- Western Institute for Research and Evaluation (W.I.R.E.)
- Zapcode Products Corp.



Utah State University Research and Technology Park

The Utah State University Research and Technology Park began operation in 1986. With a mission of providing an environment with facilities, technology, services, programs and expertise that stimulate and support the creation and growth of research and technology-based enterprises, the Utah State University Research and Technology Park houses private and public sector tenants who are primarily engaged in research and technology-oriented activities. The University also operates a technology-based Business Incubator within the park. Tenant collaboration with Utah State University for research and technology development is strongly encouraged and supported in this process.

Currently, the park has 12 buildings with a combined total of 264,260 square feet of space, housing approximately 35 companies.⁶⁵ These include:

- Convergys
- Earthfax Development
- Juniper Systems
- Letterpress Software, Inc.
- Open Net
- Siemens Electronic Design Solutions and Services
- Sorenson Media
- TeraGlobal Communications
- Terra Star, Inc.
- USU Space Dynamics Science Group

Utah State University Business Incubator

The Research and Technology Park supports new business development by providing business incubator services to fledgling companies on an "at cost" basis. These services include receptionist, secretarial support, shared office equipment, offices, conference room, business development consulting and networking to financial, marketing and management contacts.

APPENDIX R: Anchor Firms, Professional Business Services, and Venture Capital in Utah

Anchor Companies

1. Ballard Medical Products
12050 South Lone Peak Parkway
Draper, Utah 84020
Phone: (801) 572-6800
Fax: (801) 572-6999
<http://www.bmed.com/>

2. Bourns
<http://www.bourns.com/>

Bourns Integrated Technologies Division
1000 W 1400 North
Logan, UT 84341
(435) 750-7200

Bourns Sensors & Controls Division
2533 N 1500 West
Harrisville, UT 84404-2647
(801) 782-2070

3. Epixtech
400 W 5050 North
Provo, UT 84601
(801) 223-9859
<http://www.epixtech.com/>

4. Evans & Sutherland
600 Komas Dr.
Salt Lake City, UT 84108
Phone: 801-588-1000
Fax: 801-588-4500
<http://www.es.com>

5. GE OEC Medical Systems
384 Wright Brothers Drive
Salt Lake City, Utah 84116
Phone: (801) 328-9300
Fax: (801) 536-4800
<http://www.oecmed.com/>

6. Gentner Communications Corporation
1825 Research Way
Salt Lake City, UT 84119
Phone: (801) 975-7200
Fax: (801) 977-0087
<http://www.gentner.com>

7. Ingenix
2525 S Lake Park Blvd
West Valley City UT 84120-8230

(801) 982-3000
<http://www.ingenix.com/>

8. Intel Research & Development Center
3740 W 13400 South
Riverton, UT 84065-6416
(801) 445-8080
<http://www.intel.com/intel/community/ut/>

9. Iomega
1821 W. Iomega Way
Roy, UT 84067 (Map)
Salt Lake City City Guide
Phone: (801) 332-1000
Fax: (801) 332-3804
<http://www.iomega.com>

10. L3 Communications Corporation
Communication Systems West
PO Box 16850
Salt Lake City, Utah 84116-0850
(801) 594-2000
<http://www.l-3com.com/csw/>

11. Merit Medical Systems
1600 W. Merit Pkwy.
South Jordan, UT 84095
Phone: 801-253-1600
Fax: 801-253-1687
<http://www.merit.com>

12. Myriad Genetics
Myriad Genetics Inc
390 S Wakara Way
Salt Lake City, UT 84108-1214
(801) 582-3400

13. Novell
1800 South Novell Place
Provo, UT 84606
Phone: 801-861-7000
Fax: 801-228-7077
<http://www.novell.com>

14. PowerQuest
1359 N. Research Way, Bldg. K
Orem, UT 84097-2395
Phone: 801-437-8900
Fax: 801-226-8941
<http://www.powerquest.com>

15. Sonic Innovations
2795 E. Cottonwood Pkwy., Ste. 660
Salt Lake City, UT 84121-7036
Phone: (801) 365-2800
Fax: (801) 365-3000
<http://www.sonici.com/index.htm>

16. Utah Medical Products
7043 S. 300 West
Midvale, UT 84047

Phone: 801-566-1200
Fax: 801-566-2062
<http://www.utahmed.com>

17. Zevex International
4314 Zevex Park Ln.
Salt Lake City, UT 84123
Phone: 801-264-1001
Fax: 801-264-1051
<http://www.zevex.com>

Venture Capital Firms

1. Canopy Group
Phone: (801) 229-2223
Fax: (801) 229-2458
<http://www.canopy.com>

2. Cornerstone Capital Group
Phone: (801) 451-8991
Fax: (801) 451-8901
<http://www.cornerstone.com>

3. Granite Capital Partners
Phone: (801) 429-9292
Fax: (801) 426-9299
<http://www.granitecp.com>

4. New Media Venture Partners
Phone: (801) 566-1900
Fax: (801) 566-4105
<http://www.nmvp.com>

5. Peterson Ventures
Phone: (801) 359-8880
Fax: (801) 359-8840
<http://www.petersonventures.com/contact.html>

6. Utah Ventures
Phone: (801) 583-5922
Fax: (801) 583-4105
<http://www.utahventures.com>

7. vSpring
Phone: (801) 942-8999
Fax: (801) 942-1636
<http://www.vspring.com>

8. Wasatch Venture Fund
Phone: (801) 524-8939
Fax: (801) 524-8941
<http://www.wasatchvc.com>

Law Firms

1. Dorsey & Whitney LLP
170 S Main, Suite 925
Salt Lake City, UT 84111
(801) 933-7360

2. Durham Jones & Pinegar
1104 E Country Hills Drive, Suite 710
Ogden, UT 84403-2493
(801) 395-2424

3. Parr Waddoups Brown Gee & Loveless
185 South State Street, Suite 1300
Salt Lake City, UT 84111
(801) 532-7840

4. Parsons Behle & Latimer
201 S Main St Suite 1800
Salt Lake City UT 84111
(801) 532-1234

5. Stoel Rives LLP
201 South Main Street, Suite 1100
Salt Lake City, UT
(801) 328-3131

6. Wilson Sonsini Goodrich & Rosati
2825 East Cottonwood Pkwy, Suite 500
Salt Lake City, Utah 84121
Telephone: 801-990-3445
Fax: 801-990-3446
E-mail: SaltLakeCity@wsgr.com

Accounting Firms

1. Arthur Andersen LLP
15 W South Temple Suite 700
Salt Lake City UT 84101
(801) 533-0820

2. Ernst & Young
60 E. South Temple, Suite 800
Salt Lake City, UT 84111
(801) 350-3300

3. Hansen Barnett & Maxwell
345 East Broadway, Suite 200
Salt Lake City, UT 84111
(801) 532-2200

4. KPMG
60 E South Temple
Salt Lake City, UT 84111-1004
(801) 333-8000

5. PricewaterhouseCoopers LLP
Beneficial Life Tower, Suite
1700
36 South State Street
Salt Lake City, Utah 84111
Telephone: (801) 531-9666
Fax: (801) 933-8106

Underwriters

1. Goldman, Sachs & Co.
295 Chipeta Way
Salt Lake City, UT 84108-1220
(801) 884-1000

2. Raymond James Financial Services
4695 S 1900 West
Roy, UT 84067-2669
(801) 292-2090

APPENDIX S: Utah Patents 1995-1999

Source: U.S. Patent and Trademark Office Information Products Division - TAF Branch

<http://www.uspto.gov/web/offices/ac/ido/oeip/taf/tafp.html>

COMPANIES	1995	1996	1997	1998	1999	TOTAL
Individually Owned Patent	79	104	95	113	108	497
MORTON INTERNATIONAL, INC.	53	73	64	40	4	234
UNIVERSITY OF UTAH RESEARCH FOUNDATION	13	15	19	24	25	96
IOMEGA CORPORATION	0	8	13	13	33	67
BECTON, DICKINSON AND COMPANY	9	11	15	22	9	66
BAKER HUGHES INCORPORATED	8	11	9	9	17	54
MORTON THIOKOL, INC.	9	14	7	7	1	38
AUTOLIV ASP, INC.	0	0	0	11	26	37
ULTRADENT PRODUCTS, INC.	5	2	11	10	6	34
CERAMATEC, INC.	6	6	4	4	7	27
UNIVERSITY OF UTAH	4	8	8	4	3	27
UNISYS CORPORATION	4	8	8	5	2	27
MERIT MEDICAL SYSTEMS, INC.	9	3	1	8	5	26
EVANS & SUTHERLAND COMPUTER CORP.	2	5	4	7	7	25
SARCOS, INC.	1	2	9	5	5	22
SARCOS GROUP	1	3	10	7	0	21
SPECIALIZED HEALTH PRODUCTS, INC.	1	6	3	4	5	19
THERATECH INC.	3	2	3	6	4	18
MYRIAD GENETICS, INC.	0	0	2	10	3	15
LIFETIME PRODUCTS, INC.	2	5	1	3	3	14
NOVELL, INC.	0	0	2	5	7	14
FMC CORPORATION	3	0	4	5	0	12
L-3 COMMUNICATIONS CORPORATION	0	0	0	5	7	12
NPS PHARMACEUTICALS, INC.	0	3	5	1	3	12
OEC MEDICAL SYSTEMS, INC.	2	3	5	1	0	11
MEGADYNE MEDICAL PRODUCTS, INC.	0	4	3	1	2	10
UTAH MEDICAL PRODUCTS, INC.	1	2	2	2	3	10
GULL LABORATORIES, INC.	1	1	1	5	1	9
HK SYSTEMS, INC.	2	1	3	1	2	9
3COM CORPORATION	0	0	0	1	8	9
BALLARD MEDICAL PRODUCTS, INC.	1	0	3	3	1	8
DYNO NOBEL, INC.	2	1	3	0	2	8
PHILIPS ELECTRONICS NORTH AMERICA CORP.	0	1	1	3	3	8
TECHNICAL RESEARCH ASSOCIATES, INC.	3	1	1	2	1	8
BLACK DIAMOND EQUIPMENT, LTD.	1	0	0	3	3	7
EDO CORPORATION	2	1	0	3	1	7
GAS RESEARCH INSTITUTE	0	0	3	2	2	7
NEWELL OPERATING COMPANY	2	0	3	1	1	7
SARCOS L.C.	0	0	0	0	7	7
U.S. ROBOTICS MOBILE COMMUNICATION CORP.	0	0	3	4	0	7

ZEVEX, INC.	1	2	0	4	0	7
BROWNING	1	1	1	1	2	6
JAMES W. BUNGER & ASSOC., INC.	1	1	0	2	2	6
SERVI-TECH INC.	1	2	1	0	2	6
ZIMMER, INC.	1	0	1	3	1	6
ENVIROTECH PUMPSYSTEMS, INC.	1	1	0	0	4	6
BRIGHAM YOUNG UNIVERSITY	2	1	2	0	0	5
C. R. BARD, INC.	3	0	0	2	0	5
CIRQUE CORPORATION	0	1	0	2	2	5
COVOL TECHNOLOGIES, INC.	0	2	1	1	1	5
MARTIN DOOR MANUFACTURING	0	2	1	1	1	5
QUANTRONIX, INC.	1	0	2	2	0	5
SORENSEN CRITICAL CARE, INC.	0	1	1	1	2	5
STONE CONTAINER CORPORATION	1	1	1	1	1	5
UNITED STATES OF AMERICA, AIR FORCE	0	2	1	2	0	5
WESTINGHOUSE ELECTRIC CORP.	5	0	0	0	0	5

APPENDIX T: Total Patents Issued and Patent Intensity, Selected metropolitan Areas 1997

Source: Joseph Cortright & Heike Mayer. "A Comparison of High-technology Centers"
Portland State University: April 2000 Regional Connections working paper #4

Table 8: Total Patents Issued and Patent Intensity, Selected Metropolitan Areas, 1997.

Metropolitan Area	1990	1997 Growth, 1990-97	Patent Rate
San Jose	1,295	4,931	16.7%
Austin	354	1,440	17.5%
San Diego	761	1,673	9.8%
Raleigh-Durham	233	828	15.8%
Boston	2,051	3,687	7.3%
Minneapolis	1,154	2,051	7.2%
Salt Lake City	236	472	8.7%
Phoenix	493	1,182	10.9%
Sacramento	121	289	10.9%
Denver	346	581	6.5%
Seattle	573	1,275	10.0%
Portland	384	948	11.3%
Atlanta	461	1,034	10.1%
These 13 Metropolitan Areas	8,462	20,391	11.0%
Totals for All US Metro Areas	43,637	74,714	6.7%

Source: U.S. Patent & Trademark Office, 1999

Note: Patent rate is 1997 utility patents issued per 10,000 manufacturing employees.

APPENDIX U: Venture Capital Investment, 1994 to 1999

Source: Joseph Cortright & Heike Mayer. "A Comparison of High-technology Centers"
Portland State University: April 2000 Regional Connections working paper #4

Table 12: Venture Capital Investments, 1994 to 1999

REGION	Count of Investments	Percent of Total
San Jose	1,518	15.2%
Boston	1,048	10.5%
San Diego	326	3.3%
Seattle	283	2.8%
Atlanta	240	2.4%
Minneapolis	215	2.2%
Raleigh-Durham	179	1.8%
Denver	172	1.7%
Austin	168	1.7%
Phoenix	84	0.8%
Portland	78	0.8%
Salt Lake City	45	0.5%
Sacramento	17	0.2%

Source: (Zook, 1999).

Note: Data are total number of venture capital investments between 1994 and 1999 (First quarter).

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